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Mr. E. B. Abel, Prof. C. K. Adams, Mr. A. W. Ames, Pres. J. B. Angell, Hon. J. M. Ashley, Mr. Harry W. Ashley, Mr. Philip Bach, Mr. J. N. Bailey, Mr. Emil Baur, Dr. Newton Baldwin, Mr. J. E. Beal, Prof. W. W. Beman, Mr. H. D. Bennett, Mr. M. H. Brennan, Dr. W. F. Breakey, Mr. H. J. Brown, Mr. Benj. Brown, Mr. J. C. Bullis, Mr. Robt. Campbell, Prof. H. N. Chute, Prof. B. W. Cheever, Judge N. W. Cheever, Mr. Jas. Clements, Mr. S. M. Clarkson, Mr. E. W. Coddington, Mr. Wm. Condon, Hon. T. M. Cooley, Prof. M. E. Cooley, Mr. B. F. Crane, Col. H. S. Dean, Mr. Sedgwick Dean, Dr. W. H. Dorrance, Dr. S. H. Douglas, Mr. Edward Duffy, Dr. E. S. Dunster, Mr. C. Eberbach, Mr. Ottmar Eberbach, Mr. Anton Eisele, Hon. Alpheus Felch, Mr. John W. Ferdon, Prof. H. S. Frieze, Dr. G. E. Frothingham, Mr. E. K. Frueauff, Dr. C. George, Mr. J. J. Goodyear, Prof. C. E. Greene, Mr. L. Gruner, Mr. Israel Hall, Mr. Geo. Haller, Mr. A. W. Hamilton, Judge W. D. Harriman, Prof. M. W. Harrington, Rev. S. Haskell, Mr. H. W. Hayes, Mr. G. A. Hendricks, Mr. J. S. Henderson, Mr. W. R. Henderson, Mr. H. B. Henderson, Prof. A. Hennequin, Dr. W. J. Herdman, Mr. Daniel Hiscock, Mr. Chas. E. Hiscock, Mr. E. H. Hudson, Mr. H. Hutzel, Mr. J. T. Jacobs, Prof. O. C. Johnson, Prof. C. N. Jones, Dr. John Kapp, Mr. Ambrose Kearney, Mr. John Keck, Mr. T. J. Keech, Hon. E. D. Kinne, Mr. Kendall Kittredge, Mr. J. W. Knight, Mr. J. C. Knowlton, Prof. J. W. Langley, Mr. J. F. Lawrence, Mr. Christian Mack, Dr. Donald Maclean, Mr. Chas. K. McGee, Mr. Donald McIntyre, Mr. Geo. C. Mahon, Mr. E. Mann, Mr. C. H. Millen, Prof. Geo. S. Morris, Rev. John Neumann, Mr. Geo. Osius, Judge P. L. Page, Dr. A. B. Palmer, Prof. W. H. Payne, Supt. W. S. Perry, Prof. W. H. Pettee, Mr. E. A. Phillips, Mr. E. B. Pond, Mr. Allen B. Pond, Mr. Geo. H. Pond, Rev. R. B. Pope, Mr. Robt. Popkins, Prof. A. B. Prescott, Mr. M. S. Pulcipher, Hon. C. H. Richmond, Rev. W. H. Ryder, Mr. David Rinsey, Mr. J. J. Robison, Prof. H. W. Rogers, Mr. E. H. Scott, Mr. J. Austin Scott, Capt. J. F. Schuh, Mr. F. Schmid, Mr. J. M. Schaeberle, Mr. Moses Seabolt, Mr. J. Q. A. Sessions, Prof. Henry Sewall, Mr. Adam Seyler, Dr. W. B. Smith, Maj. Harrison Soule, Prof. J. B. Steere, Rev. R. H. Steele, Prof. C. H. Stowell, Mr. Jas. L. Stone, Dr. T. J. Sullivan, Mr. J. E. Sumner, Rev. J. T. Sunderland, Mr. L. D. Taylor, Prof. Calvin Thomas, Mr. W. A. Tolchard, Mr. Edward Treadwell, Dr. V. C. Vaughan, Mr. Jas. H. Wade, Mr. Wm. Wagner, Hon. Rufus Waples, Mr. Earl Ware, Mr. B. F. Watts, Mr. W. W. Watts, Prof. C. K. Wead, Mr. J. M. Wheeler, Mr. W. W. Whedon, Mr. C. H. Worden, Mr. Levi Wines, Mr. W. W. Wines, Prof. Alexander Winchell.

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Secretary.—Prof. J. W. LANGLEY.

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Chairman.—President J. B. ANGELL.

Prof. C. E. Greene, Prof. M. W. Harrington, Prof. J. W. Langley, Prof. A. B. Prescott, Prof. Henry Sewall, Prof. C. K. Wead, Prof. Alex. Winchell.

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His Honor the Mayor, Dr. John Kapp; Mr. E. H. Hudson, Mr. John F. Lawrence, Mr. Geo. H. Pond, Mr. Earl Ware.

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Chairman.—Judge N. W. CHEEVER.

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COMMITTEE ON MAILS, TELEGRAMS, AND EXPRESS.

Chairman.—Mr. J. C. KNOWLTON.

Mr. A. W. Ames, Mr. J. J. Goodyear, Mr. T. J. Keech, Mr. Allen B. Pond, Mr. M. S. Pulcipher, Mr. W. W. Watts.

COMMITTEE ON TRANSPORTATION.

Chairman—Maj. HARRISON SOULE.

Mr. E. B. Abel, Mr. H. J. Brown, Prof. M. E. Cooley, Mr. Edward Duffy, Mr. H. W. Hayes, Mr. E. A. Phillips.

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Chairman—Mr. CHRISTIAN MACK.

Dr. Newton Baldwin, Mr. Emil Baur, Mr. J. E. Beal, Prof. W. W. Beman, Mr. Benj. Brown, Mr. Robt. Campbell, Prof. B. W. Cheever, Prof. H. N. Chute, Mr. S. M. Clarkson, Col. H. S. Dean, Dr. W. H. Dorrance, Mr. O. Eberbach, Mr. A. W. Hamilton, Mr. Geo. Haller, Mr. W. R. Henderson, Mr. Chas. E. Hiscock, Mr. J. T. Jacobs, Prof. C. N. Jones, Mr. Ambrose Kearney, Mr. K. Kittredge, Mr. J. J. Robinson, Mr. E. H. Scott. Mr. Moses Seabolt, Mr. J. E. Sumner. Dr. T. J. Sullivan, Mr. W. A. Tolchard, Mr. E. Treadwell, Dr. V. C. Vaughan, Prof. C. K. Wead, Mr. C. H. Worden.

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Chairman—Prof. ALEXANDER WINCHELL.

Mr. Harry W. Ashley, Mr. Jas. Clements, Dr. D. Maclean, Hon. C. H. Richmond, Maj. H. Soule.

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Chairman—President J. B. ANGELL.

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Chairman—Mr. JAS. H. WADE.

Prof. M. E. Cooley, Dr. S. H. Douglas, Prof. O. C. Johnson, Supt. W. S. Perry, Prof. H. Sewall.

COMMITTEE ON HOTELS AND LODGINGS.

Chairman—Mr. H. D. BENNETT.

Mr. E. B. Abel, Mr. H. J. Brown, Judge W. D. Harriman, Mr. J. Q. A. Sessions.

OFFICERS ELECTED

FOR

THE BUFFALO MEETING.

PRESIDENT.

E. S. MORSE, of Salem, Mass.

VICE PRESIDENTS.

A. Mathematics and Astronomy—J. W. GIBBS of New Haven, Conn.
B. Physics—C. F. BRACKETT of Princeton, N. J.
C. Chemistry—H. W. WILEY of Washington, D. C.
D. Mechanical Science—O. CHANUTE of Kansas City, Mo.
E. Geology and Geography—T. C. CHAMBERLIN of Washington, D. C.
F. Biology—H. P. BOWDITCH of Boston, Mass.
H. Anthropology—HORATIO HALE of Clinton, Ont., Canada.
I. Economic Science and Statistics—JOSEPH CUMMINGS of Evanston, Ill.

PERMANENT SECRETARY.

F. W. PUTNAM of Cambridge, Mass.

GENERAL SECRETARY.

S. G. WILLIAMS of Ithaca, N. Y.

ASSISTANT GENERAL SECRETARY.

W. H. PETTEE of Ann Arbor, Mich.

SECRETARIES OF THE SECTIONS.

A. Mathematics and Astronomy—S. C. CHANDLER of Cambridge, Mass.
B. Physics—H. S. CARHART of Evanston, Ill.
C. Chemistry—WM. MCMURTRIE of Champaign, Ill.
D. Mechanical Science—WILLIAM KENT of Jersey City, N. J.
E. Geology and Geography—E. W. CLAYPOLE of Akron, Ohio.
F. Biology—J. C. ARTHUR of Geneva, N. Y.
H. Anthropology—A. W. BUTLER of Brookville, Ind.
I. Economic Science and Statistics—H. E. ALVORD of Mountainville, N. Y.

TREASURER.

WILLIAM LILLY of Mauch Chunk, Pa.

SPECIAL COMMITTEES OF THE ASSOCIATION.

1. *Permanent Committee on Weights, Measures and Coinage.*

F. A. P. BARNARD of New York,
B. A. GOULD of Cambridge,
J. E. HILGARD of Washington,
H. A. NEWTON of New Haven,
E. B. ELLIOTT of Washington,
JOHN TROWBRIDGE of Cambridge,
A. M. MAYER of Hoboken.

2. *Committee on Membership.*

THE MEMBERS OF THE STANDING COMMITTEE.

3. *Committee on the best methods of Science-Teaching in the Public Schools.*

JOHN EATON of Washington,
R. H. THURSTON of Hoboken,
JAMES MAC ALISTER of Philadelphia,
J. BURKITT WEBB of Ithaca,
C. M. WOODWARD of St. Louis,
C. E. BESSEY of Lincoln.

This committee has power to add to its number.

4. *Committee on the Registration of Deaths, Births, and Marriages.*

E. B. ELLIOTT of Washington,
JOHN COLLETT of Indianapolis.
E. T. COX of San Francisco,

5. *Committee on Stellar Magnitudes.*

E. C. PICKERING of Cambridge,
S. W. BURNHAM of Chicago,
ASAPH HALL of Washington,
WILLIAM HARKNESS of Washington,
E. S. HOLDEN of Madison,
SIMON NEWCOMB of Washington,
ORMOND STONE of Univ. of Va.,
C. A. YOUNG of Princeton.

6. *Committee on International Scientific Congress.*

SIMON NEWCOMB of Washington,
T. STERRY HUNT of Montreal,
G. F. BARKER of Philadelphia,
J. W. POWELL of Washington,
E. C. PICKERING of Cambridge,
IRA REMSEN of Baltimore,
C. S. MINOT of Boston.

7. *Committee on Indexing the Literature of the Chemical Elements.*

H. CARRINGTON BOLTON of Hartford,
IRA REMSEN of Baltimore,
F. W. CLARK of Washington,
A. R. LEEDS of Hoboken,
A. A. JULIEN of New York.

8. *Committee on International Congress of Geologists.*

JAMES HALL of Albany,
J. W. DAWSON of Montreal,
J. S. NEWBERRY of New York,
T. STERRY HUNT of Montreal,
C. H. HITCHCOCK of Hanover,
RAPHAEL PUMPELLY of Newport,
J. P. LESLEY of Philadelphia,
J. W. POWELL of Washington,
G. A. COOK of New Brunswick,
JOHN STEVENSON of New York,
E. D. COPE of Philadelphia,
E. A. SMITH of Tuscaloosa,
PERSIFOR FRAZER of Philadelphia,
H. S. WILLIAMS of Ithaca,
N. H. WINCHELL of Minneapolis.

9. *Committee to confer with the United States Geologist in regard to coöperation between the Government and State Geological and Topographical Surveys.*

JAMES HALL of Albany,
T. STERRY HUNT of Montreal,
J. S. NEWBERRY of New York,
N. H. WINCHELL of Minneapolis,
C. H. HITCHCOCK of Hanover,
J. P. LESLEY of Philadelphia,
G. H. COOK of Brunswick,
E. A. SMITH of Tuscaloosa,
JOSEPH LE CONTE of San Francisco.

This Committee has power to add to its number.

10. *Committee on Interchange of Courtesies between the American and British Associations for the Advancement of Science.*

C. A. YOUNG of Princeton,
J. P. LESLEY of Philadelphia,
J. W. DAWSON of Montreal,
T. STERRY HUNT of Montreal,
E. S. MORSE of Salem,
T. C. MENDENHALL of Washington.
F. W. PUTNAM of Cambridge.

11. *Committee in relation to Duty on Scientific Books.*

H. A. ROWLAND of Baltimore,
C. A. YOUNG of Princeton,
J. W. POWELL of Washington,
J. D. COX of Cincinnati,
E. S. MORSE of Salem,
S. F. BAIRD of Washington,
SIMON NEWCOMB of Washington,
T. C. MENDENHALL of Washington.

12. *Committee on Anatomical Nomenclature, with Special reference to the Brain.*

HARRISON ALLEN of Philadelphia,
H. OSBORN of Ames,
T. B. STOWELL of Cortland,
B. G. WILDER of Ithaca.

13. *Committee on the Encouragement of Researches upon the Health and Disease of Plants.*

J. C. ARTHUR of Geneva,
C. E. BESSEY of Lincoln,
T. J. BURRILL of Champaign,
W. G. FARLOW of Cambridge,
C. V. RILEY of Washington.

14. *Committee to present to the Postmaster General the importance of a change in the postal laws in relation to the transportation of Botanical specimens through the mails.*

L. F. WARD of Washington,
GEORGE VASEY of Washington,
J. W. CHICKERING, JR., of Washington.

15. *Committee on Physics Teaching.*

T. C. MENDENHALL of Washington,
W. A. ANTHONY of Ithaca,
H. S. CARHART of Evanston,
F. H. SMITH of Charlottesville,
JOHN TROWBRIDGE, of Cambridge.

16. *Auditors.*

HENRY WHEATLAND of Salem,
THOMAS MEEHAN of Germantown.

MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION OF GEOLOGISTS AND NATURALISTS.

MEETING.	DATE.	PLACE.	CHAIRMAN.	SECRETARY.	ASSIS'T SEC'Y.	TREASURER.
1st	April 2, 1840,	Philadelphia,	Edward Hitchcock,*	L. C. Beck,*		
2d	April 5, 1841,	Philadelphia,	Benjamin Silliman,*	L. C. Beck,*	B. Silliman, jr.,* C. B. Trego,*	
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*	J. D. Whitney, M. B. Williams,*	
4th	April 26, 1843,	Albany,	Henry D. Rogers,*	B. Silliman, jr.,*		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, jr.,* O. P. Hubbard,		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,*	B. Silliman, jr.,* J. Lawrence Smith,*		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, jr.,*		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,†*	Jeffries Wyman,*		B. Silliman, jr.*

* Deceased.

† Professor ROGERS, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE-PRESIDENT.	GENERAL SECRETARY.	PERMANENT SEC'Y.	TREASURER.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,*		Walter R. Johnson,*		Jeffries Wyman.*
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,*		E. N. Horsford, 1		A. L. Elwyn.*
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,* 2		L. R. Gibbs, 3		St. J. Ravenel.* 4
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,*		A. L. Elwyn.*
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. B. Rogers, 5*	S. F. Baird,	S. F. Baird. 6
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,*	S. F. Baird,	A. L. Elwyn.*
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Pierce,*		S. St. John,* 7	S. F. Baird,	A. L. Elwyn.*
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana,		J. Lawrence Smith,*	Joseph Lovering,	J. L. LeConte* 8
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.*
10th	Aug. 20, 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.*
11th	Aug. 12, 1857,	Montreal, Canada,	Alexis Caswell,* 9	Alexis Caswell,*	John LeConte,	Joseph Lovering,	A. L. Elwyn.*
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,* 10	John E. Holbrook,*†	W. M. Gillespie,* 11	Joseph Lovering,	A. L. Elwyn.*
13th	Aug. 3, 1859,	Springfield, Mass.	Stephen Alexander,*	Edward Hitchcock,*	William Chauvenet,*	Joseph Lovering,	A. L. Elwyn.*
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea,	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.*
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,	A. A. Gould,* 12	Elias Loomis, 13	Joseph Lovering,	A. L. Elwyn.†*
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.†*
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey,	Simon Newcomb, 14	Joseph Lovering,	A. L. Elwyn.†*
18th	Aug. 18, 1869,	Salem, Mass ,	J. W. Foster,*	O. N. Rood,	O. C. Marsh,	F. W. Putnam, 15	A. L. Elwyn.†*
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt, 16	T. S. Hunt,	F. W. Putnam, 17	Joseph Lovering,	A. L. Elwyn.†*
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.*,
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,*	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.*
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,	A. H. Worthen,†	C. A. White,	F. W. Putnam,	W. S. Vaux.*
23d	Aug. 12, 1874,	Hartford, Conn.,	J. L. LeConte,*	C. S. Lyman,	A. C. Hamlin,	F. W. Putnam,	W. S. Vaux.†*

1. In place of Jeffries Wyman, *not present.*
2. In place of Joseph Henry, *not present.*
3. In place of E. C. Herrick, *not present.*
4. In place of A. L. Elwyn, *not present.*
5. In place of E. C. Herrick, *not present.*
6. In place of A. L. Elwyn, *not present.*
7. In place of J. D. Dana, *not present.*
8. In place of A. L. Elwyn, *not present.*
9. In place of J. W. Bailey, *deceased.*
10. In place of Jeffries Wyman, *not present.*
11. In place of Wm. Chauvenet, *not present.*
12. In place of R. W. Gibbes, *not present.*
13. In place of W. P. Trowbridge, *not present.*
14. In place of A. P. Rockwell, *called home 1st day.*
15. In place of Joseph Lovering, *in Europe.*
16. In place of Wm. Chauvenet, *too ill to be present.*
17. In place of C. F. Hartt, *in Brazil.*

* Deceased. † Not present at the meeting.

MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENT, SECTION A.	VICE PRESIDENT, SECTION B.	CHAIRMAN OF PERMANENT SUBSECTION OF CHEMISTRY.	CHAIRMAN OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	CHAIRMAN OF PERMANENT SUBSECTION OF MICROSCOPY.	CHAIRMAN OF PERMANENT SUBSECTION OF ENTOMOLOGY.
24th	Aug. 11, 1875.	Detroit, Mich.,	J. E. Hilgard,	H. A. Newton,	J. W. Dawson,	S. W. Johnson,	L. H. Morgan,*	———	———
25th	Aug. 23, 1876.	Buffalo, N. Y.,	W. B. Rogers,*	C. A. Young,	E. S. Morse,	G. F. Barker,	L. H. Morgan,*	R. H. Ward,	———
26th	Aug. 29, 1877.	Nashville, Tenn.,	S. Newcomb,	R. H. Thurston,[1]	O. C. Marsh,	N. T. Lupton,	Daniel Wilson,†	R. H. Ward,	———
27th	Aug. 21, 1878.	St. Louis, Mo.,	O. C. Marsh,	R. H. Thurston,	Aug. R. Grote,	F. W. Clarke,	———[2]	R. H. Ward,[3]	———
28th	Aug. 27, 1879.	Saratoga, N. Y.,	G. F. Barker,	S. P. Langley,	J. W. Powell,	F. W. Clarke,[4]	Daniel Wilson,	E. W. Morley,	———
29th	Aug. 25, 1880.	Boston, Mass.,	L. H. Morgan,*	Asaph Hall,	Alex. Agassiz,	J. M. Ordway,	J. W. Powell,	S. A. Lattimore,	———
30th	Aug. 17, 1881.	Cincinnati, Ohio,	G. J. Brush,	Wm. Harkness,[7]	E. T. Cox,[8]	G. C. Caldwell,[9]	G. Mallery,	A. B. Hervey,	J. G. Morris.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF SECTION A.	SECRETARY OF SECTION B.	SECRETARY OF PERMANENT SUBSECTION OF CHEMISTRY.	SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.	SECRETARY OF PERMANENT SUBSECTION OF ENTOMOLOGY.	TREASURER.
F. W. Putnam,	S. H. Scudder,	S. P. Langley, T. C. Mendenhall,	E. S. Morse,	F. W. Clarke,	F. W. Putnam,	———	———	W. S. Vaux.*
F. W. Putnam,	T. C. Mendenhall,	A. W. Wright,	Albert H. Tuttle,	H. C. Bolton,	O. T. Mason,	E. W. Morley,	———	W. S. Vaux.*
F. W. Putnam,	Aug. R. Grote,	H. C. Bolton,	Wm. H. Dall,	P. Schweitzer,	———[2]	T. O. Summers, Jr.,	———	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,	F. E. Nipher,	George Little,	A. P. S. Stuart,	———[2]	G. J. Engelmann,	———	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,[5]	J. K. Rees,	W. H. Dall,[6]	W. R. Nichols,	J. G. Henderson,	A. B. Hervey,	———	W. S. Vaux.†*
F. W. Putnam,	J. K. Rees,	H. B. Mason,	C. V. Riley,	C. E. Munroe,	J. G. Henderson,	A. B. Hervey,	———	W. S. Vaux.*
F. W. Putnam,	C. V. Riley,	E. T. Tappan,[10]	Wm. Saunders,	A. Springer,[12]	J. G. Henderson,	W. H. Seaman,[11]	B. P. Mann,	W. S. Vaux.†*

[1] In the absence of E. C. Pickering.
[2] The Subsection united with Sec. B.
[3] In the absence of G. S. Blackie.
[4] In the absence of Ira Remsen.
[5] In the absence of George Little.
[6] In the absence of A. C. Wetherby.
[7] In the absence of A. M. Mayer.
[8] In the absence of George Engelmann.
[9] In the absence of W. R. Nichols.
[10] In the absence of John Trowbridge.
[11] In the absence of S. P. Sharples.
[12] In place of H. W. Wiley, called away.
* Deceased.
† Not present.

MEETINGS AND OFFICERS OF THE ASSOCIATION. (*Continued.*)

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENTS.				
				Section A.	Section B.	Section C.	Section D.	Section E.
31st	Aug. 23, 1883.	Montreal, Can.	J. W. Dawson,	W. A. Rogers,[1]	T.C. Mendenhall,	H. C. Bolton,	W. P.Trowbridge,	E. T. Cox,
32nd	Aug. 15, 1883.	Minneapolis, M.	C. A. Young,	W. A. Rogers,	H. A. Rowland,	E. W. Morley,	De Volsen Wood,[7]	C.H. Hitchcock,
33rd	Sept. 3, 1884.	Philadelphia, Pa.	J. P. Lesley,	H. T. Eddy,	J. Trowbridge,	J. W. Langley,	R. H. Thurston,	N. H. Winchell,
34th	Aug. 26, 1885.	Ann Arbor,Mich.	H. A. Newton,	W. Harkness,[15]	S. P. Langley,[16]	N. T. Lupton,[17]	J. Burkitt Webb,	Edward Orton,

VICE PRESIDENTS.				Permanent Secretary.	General Secretary.	Assistant Gen. Secretary.	SECRETARIES OF SECTIONS.	
Section F.	Section G.	Section H.	Section I.				Section A.	Section B.
W. H. Dall,	A. H. Tuttle,	Alex. Winchell,[2]	E. B. Elliott,	F. W. Putnam,	Wm. Saunders,	J. R. Eastman,	H. T. Eddy,	C. S. Hastings,
W. J. Beal,	J. D. Cox,	O. T. Mason,	F. B. Hough,*	F. W. Putnam,	J. R. Eastman,	Alfred Springer,	G. W. Hough,[8]	F. E. Nipher,[9]
E. D. Cope,	T. G.Wormley.	E. S. Morse,	John Eaton,	F. W. Putnam,	Alfred Springer,	C. S. Minot,[12]	G. W. Hough,	N. D. C. Hodges,
T. J. Burrill,[18]	S. H. Gage,	J. O. Dorsey,[19]	Edw. Atkinson	F. W. Putnam,	C. S. Minot,	S. G. Williams,[20]	E. W. Hyde,	B. F. Thomas,[21]

SECRETARIES OF THE SECTIONS.							Treasurer.
Section C.	Section D.	Section E.	Section F.	Section G.	Section H.	Section I.	
Alfred Springer,	J. B. Webb,[3]	H. S. Williams,[4]	Wm. Osler,[5]	Robt. Brown, jr.,	O. T. Mason,	F. B. Hough,[6*]	———*
J. W. Langley,[10]	J. B. Webb,[11]	A. A. Julien,	S. A. Forbes,	Carl Seiler,	G. H. Perkins,	Jos. Cummings,	William Lilly.
H. Carmichael,[13]	J. B. Webb,	E. A. Smith,	C. E. Bessey,	R. Hitchcock,	G. H. Perkins,[14]	C. W. Smiley,	William Lilly.
F.P.Dunnington.	C. J. H. Woodbury.	G. K. Gilbert,[22]	J. A. Lintner,[23]	W. H. Walmsley.	Erm. A. Smith,	C. W. Smiley,[24]	William Lilly.

1 In the absence of William Harkness.
2 In the absence of Daniel Wilson.
3 In the absence of C. B. Dudley.
4 In the absence of C. E. Dutton.
5 In the absence of C. S. Minot.
6 F. B. Hough was called home and J. R. Dodge acted at the close of the meeting.
7 Absent but place was not filled.
8 In the absence of W. W. Johnson.
9 In the absence of C. K. Wead.
10 W. M. McMurtrie, last three days of meeting.
11 Pro tempore.
12 In the absence of E. S. Holden.
13 In the absence of R. B. Warder.
14 In the absence of W. H. Holmes.
15 In the absence of J. M. Van Vleck.
16 In place of C. P. Brackett, resigned.
17 In the absence of W. R. Nichols.
18 In the absence of B. G. Wilder.
19 In the absence of W. H. Dall.
20 In place of C. C. Abbott, not present.
21 In place of A. A. Michelson, resigned.
22 In the absence of H. C. Lewis.
23 In place of C. H. Fernald, resigned.
24 In the absence of J. W. Chickering.

*Deceased.

COMMONWEALTH OF MASSACHUSETTS.

IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SEVENTY-FOUR.

AN ACT

To Incorporate the "American Association for the Advancement of Science."

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

Section 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding and conveying real and personal property, which it now is, or hereafter may be, possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

Section 2. Said corporation may have and hold by purchase, grant, gift or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

Section 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

Section 4. This act shall take effect upon its passage.

House of Representatives, March 10, 1874.
Passed to be enacted,
John E. Sanford, *Speaker.*

In Senate, March 17, 1874.
Passed to be enacted,
Geo. B. Loring, *President.*

March 19, 1874.
Approved,
W. B. Washburn.

Secretary's Department,
Boston, April 3, 1874.
A true copy, Attest:
David Pulsifer,
Deputy Secretary of the Commonwealth.

CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

OBJECTS.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS, FELLOWS, PATRONS AND HONORARY FELLOWS.

ART. 2. The Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

ART. 3. Any person may become a Member of the Association upon recommendation in writing by two members or fellows, and election by the Standing Committee.

ART. 4. Fellows shall be nominated by the Standing Committee from such of the members as are professionally engaged in science, or have by their labors aided in advancing science. The election of fellows shall be by ballot and a majority vote of the members and fellows present in General Session.

ART. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a Patron, and shall be entitled to all the privileges of a member and to all its publications.

ART. 6. Honorary Fellows of the Association, not exceeding three for each section, may be elected; the nominations to be made by the Standing Committee and approved by ballot in the respective sections before election by ballot in General Session. Honorary Fellows shall be entitled to all the privileges of Fellows and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been reëlected. The Standing Committee shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Committee made improper use of his membership or fellowship.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

OFFICERS.

ART. 9. The Officers of the Association shall be elected by ballot in General Session from the fellows, and shall consist of a President, a Vice President from each section, a Permanent Secretary, a General Secretary, an Assistant General Secretary, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be reëligible for the next two meetings. The term of office of Permanent Secretary shall be five years.

ART. 10. The President, or, in his absence, the senior Vice President present, shall preside at all General Sessions of the Association and at all meetings of the Standing Committee. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

ART. 11. The Vice Presidents shall be the chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own section, at such time as the Standing Committee shall determine. The Vice Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice Presidents shall have seniority in order of their continuous membership in the Association.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of these sessions. He shall receive the records from the Secretaries of the

Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting. He shall receive proposals for membership and bring them before the Standing Committee.

ART. 13. The Assistant General Secretary shall be the Secretary of the Standing Committee. He shall give to the Secretary of each Section the titles of papers assigned to it by the Standing Committee.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Standing Committee. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Standing Committee, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Standing Committee, and shall pay over to the Treasurer such unexpended funds as the Standing Committee may direct. He shall receive and hold in trust for the Association all books, pamphlets and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Standing Committee. He shall receive all communications addressed to the Association during the interval between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Standing Committee, and may employ one or more clerks at such compensation as may be agreed upon by the Standing Committee.

ART. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Standing Committee. He shall annually present to the Standing Committee an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Standing Committee, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Standing Committee.

ART. 16. The Secretaries of the Sections shall keep the records of their respective sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the Sectional Committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

ART. 17. In case of a vacancy in the office of the President, one of the Vice Presidents shall be elected by the Standing Committee as the President of the meeting. Vacancies in the offices of Vice President, Permanent Secretary, General Secretary, Assistant General Secretary, and Treasurer, shall be filled by nomination of the Standing Committee and election by ballot in General Session. A vacancy in the office of Secretary of a Section shall be filled by nomination and election by ballot in the Section.

ART. 18. The Standing Committee shall consist of the past Presidents, and the Vice Presidents of the last meeting, together with the President, the Vice Presidents, the Permanent Secretary, the General Secretary, the Assistant General Secretary, the Secretaries of the Sections, and the Treasurer of the current meeting, with the addition of one fellow elected from each Section by ballot on the first day of its meeting. The members present at any regularly called meeting of the Committee, provided there are at least five, shall form a quorum for the transaction of business. The Standing Committee shall meet on the day preceding each annual meeting of the Association, and arrange the programme for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Committee shall be held in the committee room at 9 o'clock, A. M., on each day of the meeting of the Association. Special meetings of the Committee may be called at any time by the President. The Standing Committee shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Committee. The Committee shall receive and assign papers to the respective sections; examine and, if necessary, exclude papers; decide which papers, discussions and other

proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programmes for general Sessions; suggest subjects for discussion, investigation or reports; elect members and nominate fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association.

ART. 19. The Nominating Committee shall consist of the Standing Committee, and one member or fellow elected by each of the Sections. It shall be the duty of this Committee to meet at the call of the President and nominate the general officers for the following meeting of the Association. It shall also be the duty of this Committee to recommend the time and place for the next meeting. The Vice President and Secretary of each Section shall be recommended to the Nominating Committee by a sub-committee consisting of the Vice President, Secretary, and three members or fellows elected by the Section.

MEETINGS.

ART. 20. The Association shall hold a public meeting annually, for one week or longer, at such time and place as may be determined by vote of the Association, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Standing Committee may designate.

ART. 21. General Sessions shall be held at 10 o'clock A. M., unless otherwise ordered, on every day of the meeting, Sunday excepted, and at such other times as may be appointed by the Standing Committee.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into Sections, namely:—A, *Mathematics and Astronomy;* B, *Physics;* C, *Chemistry, including its application to agriculture and the arts;* D, *Mechanical Science and Engineering;* E, *Geology and Geography;* F, *Biology;* [G, united to section F]; H, *Anthropology;* I, *Economic Science and Statistics.* The Standing Committee shall have power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice President and Secretary of the Sections comprising it.

ART. 23. Immediately on the organization of a Section there shall be three fellows elected by ballot after open nomination, who, with the Vice President and Secretary, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

ART. 25. A paper shall not be read in any Section nor Subsection until it has been received from the Standing Committee and placed on the programme of the day by the Sectional Committee.

SECTIONAL COMMITTEES.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programmes and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programmes except such as have passed the Standing Committee. No change shall be made in the programme for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the programme; but every such title, with the abstract of the paper or the paper itself, must be returned to the Standing Committee with the reasons why it was refused.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the sections, and they shall not place on the programme any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be referred by the Standing Committee to the Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready at the time assigned, the title may be dropped to the bottom of the list.

ART. 30. Whenever practicable, the proceedings and discussions at General Sessions, Sections and Subsections shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press and forward them to the Permanent Secretary within this interval, otherwise only the abstracts or titles taken from the "title blanks" will appear in the printed volume. The Standing Committee shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Standing Committee. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Standing Committee. The Standing Committee shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in the charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense, on their giving a receipt agreeing to make good any loss or damage and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Standing Committee.

Admission Fee and Assessments.

Art. 34. The admission fee for members shall be five dollars in addition to the annual assessment. On the election of any member as a fellow an additional fee of two dollars shall be paid.

Art. 35. The annual assessment for members and fellows shall be three dollars.

Art. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Standing Committee.

Art. 37. All admission fees and assessments must be paid to the Permanent Secretary, who shall give proper receipts for the same.

Accounts.

Art. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually, by Auditors appointed by the Standing Committee.

Alterations of the Constitution.

Art. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

1. The retiring President introduces the President elect, who takes the chair.
2. Formalities of welcome of the Association as may be arranged by the Local Committee.
3. Report of the list of papers entered and their reference to the Sections.
4. Other reports.
5. Announcements of arrangements by the Local Committee.
6. Election of members.
7. Election of fellows.
8. Unenumerated business.
9. Adjournment to meet in Sections.

This order, so far as applicable, to be followed in subsequent General Sessions.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.[1]

PATRONS.[2]

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22).
LILLY, GEN. WILLIAM, Mauch Chunk, Carbon Co., Pa. (28). F E
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).

MEMBERS.[3]

Aaron, Eugene M., P. O. Box 916, Philadelphia, Pa. (33). F
Abbot, Griffith Evans, Ph.D., M.D., Falls of Schuylkill, Philadelphia, Pa. (33). C H
Abbott, James, 1509 Locust St., Philadelphia, Pa. (34).
Abert, Col. James W., Newport, Ky. (31).
Abert, S. Thayer, 810 19th St., N. W., Washington, D. C. (30). A B D E I.
Adams, Chas. Francis, High School, Detroit, Mich. (34). C B
Agard, Dr. A. H., 1259 Alice St., Oakland, Alameda Co., Cal. (28).
Aher, Mrs. Mary R. Alling, care Rev. H. Alling, South Cairo, Greene Co., N. Y. (29). E F C

[1] The numbers in parentheses indicate the meeting at which the member was elected. The black letters at the end of line indicate the sections to which members elect to belong. The Constitution requires that the names of all members two or more years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the annual volume of Proceedings bound in paper. *The payment of ten dollars at one time entitles a member to the subsequent volumes to which he may be entitled, bound in cloth, or by the payment of twenty dollars, to such volumes bound in half morocco.*

[2] Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications.

The names of Patrons are to remain permanently on the list.

[3] Any Member or Fellow may become a Life Member by the payment of fifty dollars. The money derived from Life Memberships is invested as a fund, the income of which is to be used only to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the annual volume. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

Ainslie, Charles N., M. A., Rochester, Minn. (32). F
Alexander, Miss Jane, Jamaica Plain, Mass. (33.). F
Allderdice, Wm. H., U. S. Navy, care Navy Department, Washington, D. C. (33). D
Allen, Henry C., M.D., Ann Arbor, Mich. (34). C F
Allen, J. M., Hartford, Conn. (22). D
Allen, Jno. R., Linwood, Del. Co., Pa. (33).
Allison, Henry, Fort Worth, Texas (32).
Alvord, Benjamin, 2nd Lt. 20th Infantry, U. S. A., Fort Leavenworth, Kan. (33). A
Anderson, Newton M., 371 Sibley St., Cleveland, Ohio (30). B
Ansley, Clark F., Swedona, Mercer Co., Ill. (32). E H
Antisell, Thomas, M.D., 1311 Q St., N.W., Washington, D. C. (33). C E
Appleton, Rev. Edw. W., D.D., Ashbourne P. O., Montgomery Co., Pa. (28).
Apthorp, Henry, Ashtabula, Ohio (32).
Archambault, U. E., P. O. box 1944, Montreal, Can. (31).
Armstrong, Lucius H., St. Nicholas, Duval Co., Fla. (30).
Armstrong, Mrs. Lucius H., St. Nicholas, Duval Co., Fla. (30).
Atkinson, Charles Heath, Brookline, Mass. (34). D I
Atkinson, Jno. B., Earlington, Hopkins Co., Ky. (26). D
Atwood, E. S., East Orange, N. J. (29). F
Atwood, Oscar, Rutland, Vt. (31). H
Auchincloss, Wm. S., 209 Church St., Philadelphia, Pa. (29). D A
Aughey, Prof. Samuel, Univ. of Nebraska, Lincoln, Neb. (29).
Avila, A. F. de, Lavrinhas, E. F. P II., S. Paulo, Brazil (33). B
Ayers, Howard, Ann Arbor, Mich. (34). F

Babbit, John, Fredericton, N. B. (29).
Babbitt, Miss Franc E., Lock Box 1284, Coldwater, Mich. (32).
Babcock, Geo. H., 30 Cortlandt St., New York, N. Y. (33). D
Bailey, E. H. S., Lawrence, Douglas Co., Kan. (25). C E
Bailey, Prof. Liberty H., jr., Agric. College, Mich. (34). F
Baker, Achbor J., Ann Arbor, Mich. (34). F H I
Baker, Frank, M.D., 326 C St., N. W., Washington, D. C. (31). F H
Baker, Henry Brooks, 726 Ottawa St., Lansing, Mich. (34). F C I B
Baker, Prof. I. O., Univ. of Illinois, Champaign, Ill. (30.) A D
Baker, Richard D., 1414 Arch St., Philadelphia, Pa. (33). E C
Baker, Prof. T. R., Millersville, Lancaster Co., Pa. (22). B C
Balderston, C. Canby, Westtown, Chester Co., Pa. (33). B
Baldwin, Miss Mary A., Summer Ave., Cor. Kearney St., Newark, N. J. (31). E
Baldwin, Mrs. S., 3 Madison Ave., Detroit, Mich. (34). H
Balen, Abraham D., Plainfield, N. J. (31).
Ballard, Harlan H., Lenox, Mass. (31). E F
Banes, Charles H., 2021 Spring Garden St., Philadelphia, Pa. (31). D
Barber, John N., 1317 Hennepin Ave., Minneapolis, Minn. (33). F

Barclay, Robert, A.M., M.D., 3101 Olive St., St. Louis, Mo. (30).
Bardeen, Francis L., M.D., Washington College, Chestertown, Md. (32). C F B
Barge, B. F., Mauch Chunk, Pa. (33).
Barker, Mrs. Martha M., 26 Eleventh St., Lowell, Mass. (31). E H
Barnes, Charles J. (27).
Barnett, J. Davis, Port Hope, Ontario, Can. (34). D B
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Solomons, Miss Augusta I., Sumter, S. C. (31).
Solomons, Miss Kate C., Sumter, S. C. (31).
Solomons, Miss Maude C., Sumter, S. C. (31).
Soule, R. H , Frankfort, N. Y. (33). D
Soule, Wm., Ph.D., Mount Union, Ohio (33). B C E
Spafford, F. A., M.D., Flandreau, Moody Co., Dakota Terr. (29).
Spalding, Prof. Volney M., Ann Arbor, Mich. (34). F
Speck, Hon. Charles, St. Louis, Mo. (27).
Spence, Mrs. E. Jane, Springfield, Ohio (30).
Spencer, Geo. S., St. Cloud, Minn. (32). E
Sperry, Chas., Port Washington, L. I. (33). D A B C E I
Sperry, Prof. Lyman B., Northfield, Minn. (32).
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SPRAGUE, C. H., Malden, Mass. (29).
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Stæbner, Fred W., Westfield, Mass. (28). E C F
Stam, Colin F., Chestertown, Md. (33). C F
Starr, Charles S., M.D., Rochester, N. Y. (31).
Stearns, Winfrid Alden, Amherst, Mass. (23). F
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Steere, Prof. Jos. B., Ann Arbor, Mich. (34). F H
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Stockbridge, Levi, Amherst, Mass. (31).
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Straight, Prof. H. H., Normal Park, Chicago, Ill. (25).
Strieby, Prof. William, Colorado Springs, Col. (31).

Sullivan, J. A., Malden, Mass. (27). A
Sullivan, James F., 1800 Spring Garden St., Philadelphia, Pa. (33).
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Tackabury, Geo. N., Canastota, N. Y. (34).
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Taylor, Franklin, Philadelphia, Pa. (33).
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Thompson, Prof. Chas. O., Terre Haute, Ind. (29).
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Thompson, Maurice, Crawsfordsville, Ind. (34). E F
Thompson, S. A., Minneapolis, Minn. (32).
Thompson, W. W., care Jeffras Seely & Co., Cincinnati, Ohio (30).
Thomson, Prof. A., Ames, Iowa (21).
Thorburn, John, LL. D., Ottawa, Ont., Can. (29). F H
Thornton, Prof. Wm. M., Univ. of Virginia, Va. (33). D A
Thurber, Miss Elizabeth, Plymouth, Mass. (22).
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Todd, Prof. James E., Tabor, Fremont Co., Iowa (22). E F
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Tyler, John M., Amherst, Mass. (29).

Vail, Prof. Hugh D., Santa Barbara, Cal. (18).
Valentine, Benj. B., Richmond, Va. (33). H
Valentine, Edw. P., Richmond, Va. (33). H
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Weaver, Lemuel, Urbana, Ohio (32).
Webb, Miss Sarah E., Elizabeth, N. J. (33). H F
Weeden, Hon. Joseph E., Randolph, N. Y. (31).
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Wheeler, Moses D., M.E., Stapleton, Richmond Co., N. Y. (35). D
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Rains, Geo. W., M.D., LL.D., Augusta, Ga. (29). B C
Randolph, A. F., Fredericton, N. B. (29).
Randolph, L. S., Fernandina, Fla. (33). D
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Redway, Prof. J.W., Washington Heights, Station M, N. Y. (33). E C F
Reed, Charles J., Burlington, Iowa (34). C B
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Reemelin, Charles, Cincinnati, Ohio (34). I
Reese, Jacob, 78 Diamond St., Pittsburgh, Pa. (33). D B
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Reynolds, Sheldon, Wilkes Barre, Pa. (33). H
Rice, Herbert S., Lawrence, Mass. (32). D C
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Richmond, Geo. B., San Diego, Cal. (34). C B
Ricketts, Prof. Palmer C., Rensselaer Polytechnic Inst., Troy, N. Y (33). D A
Ricketts, Col. R. Bruce, Wilkes Barre, Pa. (33). E
Rideout, Bates S., Lewiston, Me. (31). E H
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Riley, Mrs. Susan, Mobile, Ala. (31).
Ringueberg, Eugene N. S., Lockport, N. Y. (33). E F
Ripley, George C., Minneapolis, Minn. (32).
Ripley, Mrs. George C., Minneapolis, Minn. (32).
Rivera, José de, Inwood-on-the-Hudson, New York, N. Y. (29).

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Roberts, Thomas S., 27 North 8th St., Minneapolis, Minn. (31). F
Robertson, Andrew, Montreal, Can. (31).
Robertson, Col. D. A., St. Paul, Minn. (32).
Robertson, Thomas D., Rockford, Ill. (10). E H
Robeson, Henry B., care Mills, Robeson & Smith, 34 Wall St., New York, N. Y. (29).
Robinson, Prof. Franklin C., Brunswick, Me. (29). C D
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Robinson, Prof. Thomas, Howard Univ., Washington, D. C. (33). B C A
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Roeder, Prof. F. A., Ohio Medical College, Cincinnati, Ohio (30).
Rogers, A. J., Milwaukee High School, Milwaukee, Wis. (34). B C
Rogers, Dr. H. Raymond, Dunkirk, N. Y. (30). B
Rolfe, Charles W., Univ. of Illinois, Champaign, Ill. (32).
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Rothrock, Prof. Jos. T., West Chester, Pa. (33). F
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Sage, John H., Portland, Conn. (23). F
Sanborn, Prof. Jeremiah Wilson, Mo. Agric. Coll., Columbia, Mo. (31).
Sanborn, Rev. John W., Albion, N. Y. (33). H
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Sands, Ferdinand, care Oakes Manufacturing Co., Steinway, Queens Co., L. I. (33). C
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Scammon, J. Young, Chicago, Ill. (17).
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FELLOWS.[2]

Abbe, Professor Cleveland, Army Signal Office, Washington, D. C. (16). 18[illegible]. **B A**

Abbott, Dr. Chas. C., Trenton, N. J. (29). 1883. **F H**

Abbott, Miss Helen C. De S., 1509 Locust St., Philadelphia, Pa. (33). 1883. **C F**

Agnew, Dr. Cornelius R., 266 Madison Ave., New York, N. Y. (32). 1885.

Alden, Prof. Geo. L., Worcester, Mass. (33). 1885. **D**

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Allen, Joel A., American Museum of Natural History, Central Park, New York (18). 18[illegible]. **F**

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Ammen, [illegible] S. Navy, Annendale, Prince George [illegible] **E**

[illegible] **H**

[illegible] N. Y. (33). 1883. **B**

[illegible] **F**

[illegible] Pa. (33). 1883. **E**

[illegible] **E**

[illegible] **I D**

[illegible] **C**

[illegible] **B**

[illegible] **F**

BARKER, PROF. G. F., Univ. of Penn., Philadelphia, Pa. (13). 1875. **B C**

Barnard, Edward E., Observatory of Vanderbilt University, Nashville, Tenn. (26). 1883. **A**

Barnard, F. A. P., President Columbia College, New York, N. Y. (7). 1874. **B D I A F**

Barnard, Prof. Wm. S., U. S. Department Agriculture, Washington, D. C. (24). 1880. **F C D**

Barnes, Prof. Chas. R., 297 Columbia St., Lafayette, Ind. (33). 1885. **F**

Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28). 1883. **C**

Bartlett, John R., Commander U. S. N., Navy Dep't, Washington, D. C. (30). 1882. **E B**

Bassett, Homer F., Waterbury, Conn. (23). 1874. **F**

Batchelder, Dr. J. H., Salem, Mass. (18). 1874. **C D**

Batchelder, John M., 3 Divinity Avenue, Cambridge, Mass. (8). 1875. **B D I**

Bausch, Edward, Rochester, N. Y. (26). 1883. **A B C F**

Bayne, Herbert A., Ph.D., Royal Military College, Kingston, Ont. (29). 1885. **C**

Beal, Prof. Wm. James, Agricultural College, Ingham Co., Mich. (24). 1880. **F**

Beardsley, Prof. Arthur, Swarthmore College, Swarthmore, Del. Co., Pa. (33). 1885. **D**

Bell, Dr. Alex. Graham, Scott Circle, 1500 Rhode Island Ave., Washington, D. C. (26). 1879. **B H I**

Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31). 1885. **H**

Bell, Samuel N., Manchester, N. H. (7). 1874.

Bessey, Prof. Charles E., Univ. of Nebraska, Lincoln, Neb. (21). 1880. **F**

Beyer, Dr. Henry G., U. S. N., U. S. National Museum, Washington, D. C. (31). 1884. **F**

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Blake, Prof. Eli W., jr., Brown Univ., Providence, R. I. (15). 1874. **B**

Blake, Francis, Auburndale, Mass. (23). 1874. **B A**

Blake, Prof. John R., Greenwood, S. C. (29). 1884. **B A**

Boardman, Mrs. William D., 38 Kenilworth St., Roxbury, Mass. (28). 1885. **E H**

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Borden, Spencer, Fall River, Mass. (29). 1882. **B C I**
Bourke, John G., Capt. 3d Cavalry, U. S. A., care of Adj. Gen. U. S. A., Washington, D. C. (33). 1885. **H**
Bouvé, Thos. T., Boston Soc. Nat. Hist., Boston, Mass. (1). 1875. **E**
Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. **F B H**
Bowditch, Henry I., M.D., 113 Boylston St., Boston, Mass. (2). 1875. **F H**
Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.
Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19). 1875. **B**
Brackett, Solomon H., St. Johnsbury, Vt. (29). 1884. **B A**
Brashear, Jno. A., 3 Holt St., Pittsburgh, S. S., Pa. (33). 1885. **A B D**
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Brewster, William, 61 Sparks St., Cambridge, Mass. (29). 1884. **F**
Brinton, D. G., M.D., Media, Pa. (33). 1885. **H**
Britton, N. L., Columbia College, New York, N. Y. (29). 1882. **F E**
Broadhead, Garland Carr, Pleasant Hill, Cass Co., Mo. (27). 1879. **E**
Bross, Hon. Wm., Tribune Office, Chicago, Ill. (7). 1874. **E H**
Brown, Robert, jr., care of Yale College Observatory, New Haven, Conn. (11). 1874.
Brown, Mrs. Robert, jr., New Haven, Conn. (17). 1874.
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Burnham, S. W., 3573 Vincennes Ave., Chicago, Ill. (25). 1877. **A**
Burr, Prof. William H., Troy, N. Y. (31). 1883.
Burrill, Prof. T. J., Univ. of Illinois, Champaign, Ill. (29). 1882. **F**
Butler, A. W., Brookville, Franklin Co., Ind. (30). 1885. **F H**

Caldwell, Prof. Geo. C., Cornell University, Ithaca, N. Y. (23). 1875. **C**
Canby, William M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878. **F**
Carhart, Prof. Henry S., Northwestern University, Evanston, Ill. (29). 1881. **B A**
Carmichael, Prof. Henry, Bowdoin College, Brunswick, Me. (21). 1875.
Carpenter, Lieut. W. L., U. S. A., Dunkirk, N. Y. (24). 1877. **F E**
Carpmael, Charles, Director of Magnetic Observatory, Toronto, Can. (31). 1883.
Carr, Lucien, Peabody Museum Archæology and Ethnology, Cambridge, Mass. (25). 1877. **H**
Case, Col. Theo. S., Kansas City, Mo. (27). 1883. **H B**
Chamberlin, T. C., U. S. Geological Survey, Washington, D. C. (21). 1877. **E B F H**
Chandler, Prof. C. F., School of Mines, Columbia Coll., 50th St. cor. 4th Ave., New York, N. Y. (19). 1875. **C**
Chandler, Prof. Charles Henry, Ripon, Wis. (28). 1883. **A B**
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Chandler, Prof. W. H., South Bethlehem, Pa. (19). 1874. **C**

Chanute, O., Kansas City, Mo. (17). 1877. **D I**
Chase, Prof. Pliny E., Haverford College P. O., Pa. (18). 1884. **A B**
Chester, Prof. Albert H., Hamilton College, Clinton, N. Y. (29). 1882. **C F**
Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22). 1877. **F I**
Chittenden, Russell H., Ph.D., New Haven, Conn. (29). 1882. **C F**
Clapp, Miss Cornelia M., Mt. Holyoke Seminary, South Hadley, Mass. (31). 1883. **F**
Clark, Alvan G., Cambridgeport, Mass. (28). 1880. **A B**
Clark, Prof. John E., Mathematics, Yale College, New Haven, Conn. (17). 1875. **A**
Clarke, Miss Cora H., Jamaica Plain, Mass. (29). 1884. **F I**
Clarke, Prof. F. W., U. S. Geological Survey, Washington, D. C. (18). 1874. **C**
Claypole, Prof. Edw. W., Buchtel Coll., Akron, Ohio (30). 1882. **E F**
Coffin, Prof. John H. C., U. S. Navy, Washington, D. C. (1). 1874. **A**
Coffin, Prof. Selden J., Lafayette College, Easton, Pa. (22). 1874. **A I**
Collett, Prof. John, Chief Indiana Bureau of Statistics of Geology, Newport, Ind. (17). 1874.
Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y. (28). 1880.
Comstock, J. Henry, Cornell Univ., Ithaca, N. Y. (28). 1882. **F**
Comstock, Milton L., 641 Academy St., Galesburg, Ill. (21). 1874. **A**
Comstock, Prof. Theo. B., Prof. of Mining Engineering, Univ. of Illinois, Champaign, Ill. (24). 1877. **D E B**
Cook, Prof. A. J., Agricultural College, Mich. (24). 1880. **F**
Cook, Prof. George H., New Brunswick, N. J. (4). 1875. **E**
Cooley, Prof. Le Roy C., Vassar College, Poughkeepsie, N. Y. (19). 1880. **B C**
Cope, Prof. Edward D., 2100 Pine St., Philadelphia, Pa. (17). 1875. **F E**
Coulter, Prof. John M., Wabash Coll., Crawfordsville, Ind. (32). 1884. **F**
Cox, Prof. Edward T., New Harmony, Ind. (19). 1874. **E**
Cox, Hon. Jacob D., Gilman Ave., Mt. Auburn, Cincinnati, Ohio (30). 1881. **F**
Coxe, Eckley B., Drifton, Luzerne Co., Pa. (23). 1879. **D E**
Crandall, Prof. A. R., Lexington, Ky. (29). 1883. **E F**
Crocker, Susan E., M.D., Lawrence, Mass. (21). 1874. **E F**
Crosby, Prof. Wm. O., Boston Society of Natural History, Boston, Mass. (29). 1881. **E**
Cross, Prof. Chas. R., Mass. Institute Technology, Boston, Mass. (29). 1880. **B**
Cummings, Rev. Joseph, D.D., President Northwestern University, Evanston, Ill. (13). 1874. **I H**
Cutting, Hiram A., M.D., State Geologist, Lunenburgh, Vt. (17). 1874. **E F**

Dabney, Chas. W., jr., Ph.D., Agricultural Experiment Station, Raleigh, N. C. (30). 1882. **C B E**

Dall, Mrs. Caroline H., 1667 31st St., Washington, D. C. (18). 1874. **F H**
Dall, William H., Smithsonian Institution, Washington, D. C. (18). 1874. **H F**
Dana, Edward Salisbury, New Haven, Conn. (23). 1875. **B E**
Dana, Prof. James D., New Haven, Conn. (1). 1875. **E**
Danforth, Edward, Department of Public Instruction, Elmira, N. Y. (11). 1874. **E I H A B**
Davenport, B. F., M.D., 751 Tremont St., Boston, Mass. (29). 1883. **C**
Davidson, Prof. Geo., Asst. U. S. Coast and Geodetic Survey, San Francisco, Cal. (29). 1881. **A B D**
Davis, Wm. Morris, Cambridge, Mass. (33). 1885. **E B**
Dawson, Sir William, Principal McGill College, Montreal, Can. (10). 1875. **E**
Day, F. H., M.D., Wauwatosa, Wis. (20). 1874. **E H F**
Dean, George W., P. O. Box 92, Fall River, Mass. (15). 1874. **A**
Diller, J. Silas, U. S. Geol. Survey, Washington, D. C. (29). 1884. **E**
Dimmock, George, Cambridge, Mass. (22). 1874. **F**
Dinwiddie, Robert, 117 W. 43d St., New York, N. Y. (1). 1874. **F**
Dodge, Prof. James A., University of Minnesota, Minneapolis, Minn. (29). 1884. **C E**
Dodge, J. Richards, Washington, D. C. (31). 1884. **I H**
Dolbear, A. Emerson, College Hill, Mass. (20). 1880. **B**
Dorsey, Rev. J. Owen, Box 591, Washington, D. C. (31). 1883. **H**
Douglass, Andrew E., P. O. Box 605, New York, N. Y. (31). 1885. **H**
Dow, Capt. John M., 69 Seventh Ave., New York, N. Y. (31). 1884. **F H**
Draper, Dan'l, Ph.D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29). 1881. **B D F A**
Drown, Prof. Thos. M., Mass. Institute Technology, Boston, Mass. (29). 1881. **C**
Du Bois, Prof. Aug. J., New Haven, Conn. (30). 1882. **A B D**
Dudley, Charles B., Altoona, Pa. (23). 1882. **C B D**
Dudley, P. H., 66½ Pine St., New York, N. Y. (29). 1884.
Dudley, Wm. L., Miami Med. College, Cincinnati, Ohio (28). 1881. **C**
Dudley, Prof. Wm. R., Ithaca, N. Y. (29). 1883. **F**
Dunnington, Prof. F. P., University of Virginia, Va. (26). 1880. **C**
Dwight, Prof. William B., Vassar College, Poughkeepsie, N. Y. (30). 1882. **E F**
Dwyer, John, M.D., Hartford, Conn. (23). 1874.

Eads, Jas. B., 34 Nassau St., New York, N. Y. (27). 1879. **D**
Eastman, Prof. J. R., U. S. Naval Observatory, Washington, D. C. (26). 1879. **A**
Eaton, Prof. D. G., 55 Pineapple St., Brooklyn, N. Y. (19). 1874. **B E**
Eaton, Prof. James R., Liberty, Mo. (29). 1885. **C B E**
Eaton, Hon. John, U. S. Commissioner of Education, Washington, D. C. (25). 1883. **I**

Eddy, Prof. H. T., Univ. of Cincinnati, Cincinnati, O. (24). 1875. **A B D**
Edison, Thos. A., Menlo Park, N. J. (27). 1878.
Egleston, Prof. Thomas, 35 W. Washington Square, New York, N. Y. (27). 1879. **C D E**
Eimbeck, William, U. S. C. S., Washington, D. C. (17). 1874. **A B D**
Elkin, William L , Yale Coll. Observ., New Haven, Conn. (33). 1885. **A**
Elliott, Arthur H., School of Mines, Columbia College, New York, N. Y. (23). 1880. **C**
Elliott, Ezekiel B., Government Actuary, Treasury Dep't, Washington, D. C. (10). 1874. **I**
Emerson, Prof. Benjamin K., Amherst, Mass. (19). 1877. **E F**
Emerson, Prof. C. F., Dartmouth Coll., Hanover, N. H. (22). 1874. **B A**
Emerton, James H., New Haven, Conn. (18). 1875. **F**
Emery, Albert H., Stamford, Conn. (29). 1884. **D B**
Emmons, S. F., U. S. Geol. Survey, Washington, D. C. (26). 1879. **E**
Engelmann, George J., M.D., 3003 Locust St., St. Louis, Mo. (25). 1875. **F H**
Ernst, Carl W., 298 Commonwealth Ave., Boston, Mass. (23). 1874. **I H**
Evans, Asher B., 500 Pine St., Lockport, N. Y. (19). 1874. **A**

Fairbanks, Henry, Ph.D., St. Johnsbury, Vt. (14). 1874. **B D A**
Fairchild, H. L., Sec'y N. Y. Acad. Sciences, 102 E. 52d St., New York, N. Y. (28). 1883. **E F**
Fanning, John T., Manchester, N. H. (29). 1885. **D**
Farlow, Dr. W. G., 29 Holyoke House, Boston, Mass. (20). 1875. **F**
Farmer, Moses G., Torpedo Station, Newport, R. I. (9). 1875.
Ferguson, Maj. Thos. B., 1435 Massachusetts Ave., Washington, D. C. (28). 1881. **F**
Fernald, Prof. Charles H., State Agricultural College, Orono, Me. (22). 1881. **F E**
Fernald, Prof. M. C., State Agric. College, Orono, Me. (22). 1883. **B A**
Ferrel, Wm., Army Signal Office, Washington, D. C. (11). 1875. **A B**
Ficklin, Prof. Joseph, Univ. of Missouri, Columbia, Mo. (20). 1878. **A B**
Fitch, Edward H., Jefferson, Ashtabula Co., Ohio (11). 1874. **I E**
Fletcher, Miss Alice C., care Peabody Museum, Cambridge, Mass. (29). 1883. **H**
Fletcher, James, Dep't of Agriculture, Ottawa, Can. (31). 1883. **F**
Fletcher, Dr. Robert, Surgeon General's Office, U. S. A., Washington, D. C. (29). 1881. **F H**
Flint, James M., Surgeon U. S. N., Navy Dep't, Washington, D. C. (28). 1882. **F**
Foote, Dr. A. E., 1223 Belmont Ave., Philadelphia, Pa. (21). 1874. **E C**
Forbes, Prof. S. A., Univ. of Illinois, Champaign, Ill. (27). 1879. **F**
Foye, Prof. J. C., Lawrence Univ., Appleton, Wis. (29). 1884. **C B**
Frazer, Dr. Persifor, 917 Clinton St., Philadelphia, Pa. (24). 1879. **E C**
Frazier, Prof. B. W., The Lehigh University, Bethlehem, Pa. (24). 1882. **E C**

Freeman, Spencer H., Adelbert College, Cleveland, Ohio (29). 1883. **B A**
French, Prof. Thomas, jr., No. 2 Chester Block, Auburn St., Cincinnati, Ohio (30). 1883. **B**
Frisby, Prof. Edgar, U. S. N. Observ., Washington, D. C. (28). 1880. **A**
Fuller, Andrew S., Ridgewood, Bergen Co., N. J. (24). 1882. **F**

Gage, Simon Henry, Ithaca, N. Y. (28). 1881. **F**
Gannett, Henry, U. S. Geological Survey, Washington, D. C. (33). 1884. **E I A**
Gardiner, Rev. Frederic, D.D., Middletown, Conn. (23). 1874. **C B**
Gardiner, James T., Director N. Y. State Survey, Albany, N. Y. (25). 1879. **E**
Garland, Rev. Dr. L. C., Chancellor Vanderbilt University, Nashville, Tenn. (25). 1877. **B**
Garman, Samuel, Museum Comparative Zoology, Cambridge, Mass. (20). 1874. **F E**
Gatschet, Albert S., P. O. Box 591, Washington, D. C. (30). 1882. **H**
Genth, Dr. F. A., University of Pennsylvania, Philadelphia, Pa. (24). 1875. **C E**
Gibbs, Prof. J. Willard, New Haven, Conn. (33). 1885. **B**
Gilbert, G. K., Box 591, Washington, D. C. (18). 1874. **E**
Gillman, Henry, Detroit, Mich. (24). 1875. **H F**
Gilman, Daniel C., President Johns Hopkins University, Baltimore, Md. (10). 1875. **E H**
Goessman, Prof. C. A., Mass. Agric. Coll., Amherst, Mass. (18). 1875. **C**
Goldschmidt, S. A., Ph.D., 55 Broadway, New York, N. Y. (24). 1880. **C E B**
Gooch, Frank A., U. S. Geol. Survey, Washington, D. C. (25). 1880. **C**
Goodfellow, Edward, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (24). 1879. **A H**
Gould, Dr. B. A., Cambridge, Mass. (2) 1875. **A B**
Grant, Mrs. Mary J., Brookfield, Conn. (23). 1874. **A**
Gratacap, L. P., Ph.B., 77th St. and 8th Ave., New York, N. Y. (27). 1884. **C E F**
Gray, Prof. Asa, Botanic Gardens, Cambridge, Mass. (1). 1875. **F**
Gray, Elisha, Sc.D., Highland Park, Ill. (32). 1883. **B**
Green, Traill, M.D., Easton, Pa. (1). 1874. **C F**
Grimes, J. Stanley, 81 Randolph St., Chicago, Ill. (17). 1874. **E H**
Grinnan, A G., Rapidan Station, Va. Mid. R. R., Va. (7). 1875.
Grinnell, George Bird, 40 Park Row, New York, N. Y. (25). 1885. **F E**
Gulley, Prof. Frank A., Agricultural College, Oktibbeha Co., Miss. (30). 1883.

Hagen, Dr. Hermann A., Museum Comparative Zoology, Cambridge, Mass. (17). 1875. **F**
Hale, Horatio, Clinton, Ontario, Can. (30). 1882. **H**
Hall, Prof. Asaph, U. S. Naval Observ., Washington, D. C. (25). 1877. **A**
Hall, Prof. C. W., Univ. of Minnesota, Minneapolis, Minn. (28). 1883. **E**

Hall, Prof. Edwin H., 5 Avon St., Cambridge, Mass. (29). 1881. **B**
Hall, Prof. James, Albany, N. Y. (1). 1875. **E F**
Hall, Prof. Lyman B., Haverford College, Pa. (31). 1884. **C**
Halsted, Byron D., Agricultural College, Ames, Iowa (29). 1883. **F**
Hamlin, Dr. A. C., Bangor, Me. (10). 1874. **C E H**
HANAMAN, C. E., Troy, N. Y. (19). 1883. **F**
Hardy, Prof. A. S., Dartmouth College, Hanover, N. H. (28). 1883. **A**
Harger, Oscar, 14 University Place, New Haven, Conn. (25). 1879. **F E**
HARKNESS, PROF. WILLIAM, U. S. N. Observatory, Washington, D. C. (26). 1878. **A B C D**
Harrington, Prof. Mark W., Ann Arbor, Mich. (22). 1875. **A B**
Harrison, Dr. B. F., Wallingford, Conn. (11). 1874. **E C**
Hart, Edw., Ph.D., Easton, Pa. (33). 1885.
Hasbrouck, Prof. I. E., 364 Carlton Ave., Brooklyn, N. Y. (23). 1874. **D A I**
Hastings, C. S., Sheffield Scientific School of Yale College, New Haven, Conn. (25). 1878. **B**
Haupt, Prof. Lewis M., University of Pennsylvania, Philadelphia, Pa. (32). 1885. **I D E**
Hayden, Dr. F. V., 1910 Arch St., Philadelphia, Pa. (29). 1881.
Haynes, Henry W., 239 Beacon St., Boston, Mass. (28). 1884. **H**
Hazen, Wm. B., Brig. and B'vt Maj. Gen'l, Chief Signal Officer, U. S. A., Washington, D. C. (30). 1882. **I**
Hedrick, B. S., Examiner U. S. Patent Office, Washington, D. C. (19). 1874. **A B C**
Heilprin, Prof. Angelo, Acad. Nat. Sciences, Philadelphia, Pa. (33). 1885. **E F**
Hendricks, J. E., Des Moines, Iowa (29). 1885. **A**
Henshaw, Henry W., Bureau of Ethnology, Washington, D. C. (24). 1877. **H**
Hering, Rudolph, 326 Walnut St., Philadelphia, Pa. (33). 1885. **D E I**
Herrick, Clarence L., Granville, Ohio (31). 1884. **F E**
Hervey, Rev. A. B., Taunton, Mass. (22). 1879. **F**
Hicks, Prof. Lewis E., State University Lincoln, Neb. (31). 1885. **E F**
Hilgard, Prof. E. W., University of California, Berkeley, Cal. (11). 1874. **C E B**
Hilgard, Prof. J. E., Washington, D. C. (4). 1874.
Hill, Franklin C., P. O. Box 338, Princeton, N. J. (29). 1881. **E F**
Hill, Rev. Dr. Thomas, 738 Congress St., Portland, Me. (3). 1875. **A**
Himes, Prof. Charles F., Carlisle, Pa. (29). 1882. **B C**
Hinrichs, Prof. Gustavus, State University, Iowa City, Iowa (17). 1874.
Hitchcock, Prof. Charles H., Hanover, N. H. (11). 1874. **E**
Hitchcock, Romyn, Washington, D. C. (29). 1881. **C B**
Hoadley, J. C., 28 State St., Room 28, Boston, Mass. (29). 1884. **D B**
Hodges, N. D. C., Editorial office of Science, 47 Lafayette St., New York, N. Y. (29). 1882. **B**
Hoffman, Dr. Fred., 183 Broadway, New York, N. Y. (28). 1881. **C F**

Holden, Prof. E. S., President University of Cal., Berkeley, Cal. (23). 1875. **A**

Holman, Silas W., Massachussetts Institute of Technology, Boston, Mass. (31). 1883. **B**

Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29). 1881. **H**

Holmes, Wm. H., Bureau of Ethnology, Smithsonian Institution, Washington, D. C. (30). 1883. **H**

Horsford, Prof. E. N., Cambridge, Mass. (1). 1876. **C E**

Hosea, Lewis M., Johnston Building, Cincinnati, Ohio (30). 1883.

Hotchkiss, Major Jed., Staunton, Va. (31). 1883. **E H I**

Hough, Prof. G. W., Director Dearborn Observatory, Chicago, Ill. (15). 1874. **A**

Hovey, Rev. Horace C., 1519 Park Avenue, Minneapolis, Minn. (29). 1883. **E H**

Hoy, Philo R., M.D., Racine, Wis. (17). 1875. **F H**

Hunt, George, Providence, R. I. (9). 1874.

Hunt, Dr. T. Sterry, Montreal, Canada (1). 1874. **C E**

Huntington, Prof. J. H., Boston, Mass. (19). 1874.

Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18). 1875. **E**

Hyatt, James, Stanfordville, Duchess Co., N. Y. (10). 1874. **I F E B**

Hyde, Prof. E. W., Walnut Hills, Cincinnati, Ohio (25). 1881. **A**

Iddings, Joseph P., U. S. Geol. Survey, Washington, D. C. (31). 1884. **E**

Irving, Roland D., Wis. State Geol. Survey, Madison, Wis. (26). 1879. **E**

James, Jos. F., 168 Broadway, Cincinnati, Ohio (30). 1882. **F E**

James, Horace F., 1826 Chestnut St., Philadelphia, Pa. (29). 1884. **F H**

Jeffries, B. Joy, M.D., 13 Chestnut St., Boston, Mass. (29). 1881. **F H**

Jenks, Rev. E., New Haven, Conn. (33). 1883. **C**

[illegible] Mass. (27). 1874. **D**

[illegible] Mass. (31). 1874. **B**

[illegible] Newport, R. I.

[illegible] **E H F**

[illegible] 1874. **C**

[illegible] **A**

[illegible] N. Y. (24).

[illegible] **C**

[illegible] **F**

[illegible] **A**

[illegible] **I**

[illegible] **A F**

[illegible] **C**

[illegible]

[illegible] **C**

Kunz, G. F., with Tiffany & Co., New York, N. Y. (29). 1883. **E H C**

LaFlesche, Francis, Indian Bureau, Interior Dep't, Washington, D. C. (33). 1885. **H**
Lambert, Rev. Thomas R., D.D., Charlestown, Mass. (18). 1874.
Landreth, Prof. Olin H., Vanderbilt Univ., Nashville, Tenn. (28). 1883.
Langdon, Dr. F. W., 65 West 7th St., Cincinnati, Ohio (30). 1882. **F H**
Langley, Prof. J. W., Univ. of Mich., Ann Arbor, Mich. (23). 1875. **C B**
Langley, Prof. S. P., Director of Observatory, Allegheny, Pa. (18). 1874. **A B**
Lanza, Prof. Gaetano, Mass. Institute of Technology, Boston, Mass. (29). 1882. **D A B**
Larkin, Edgar L., New Windsor, Mercer Co., Ill. (28). 1883. **A**
Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15). 1874. **C**
Lawrence, George N., 45 E. 21st St., New York, N. Y. (7). 1877. **F**
Lazenby, Prof. Wm. R., Columbus, Ohio (30). 1882. **B I**
Lea, Dr. Isaac, 1622 Locust St., Philadelphia, Pa. (1). 1875. **E**
LeConte, Prof. Joseph, Univ. of Cal., Berkeley, Cal. (29). 1881. **E F**
Ledoux, Albert R., Ph.D., 10 Cedar St., New York, N. Y. (26). 1881. **C**
Leeds, Prof. Albert R., Stevens Institute, Hoboken, N. J. (23). 1874. **C F**
Lehman, G. W., Ph.D., 57 S. Gay St., Baltimore, Md. (30). 1885. **C B**
Leonard, N. R., State Univ., Iowa City, Iowa (21). 1875. **A B**
Lesley, Prof. J. Peter, State Geologist of Pennsylvania, 1008 Clinton St., Philadelphia, Pa. (2). 1874. **E**
Lewis, Prof. H. Carvill, High St., Germantown, Pa. (26). 1880. **E**
Lilly, Gen. Wm., Mauch Chunk, Carbon Co., Pa. (28). 1882. (Patron). **F E**
Lindsley, Dr. J. Berrien, Nashville, Tenn. (1). 1874. **F**
Lintner, J. A., N. Y. State Entomologist, Room 27, Capitol, Albany, N. Y. (22). 1874. **F**
Litton, Abram, 2220 Eugenia St., St. Louis, Mo. (28). 1879. **C**
Lockwood, Rev. Samuel, Freehold, Monmouth Co., N. J. (18). 1875. **F B A**
Loomis, Prof. Elias, New Haven, Conn. (1). 1874. **A B**
Lord, Prof. Nat. W., State Univ., Columbus, Ohio (29). 1881. **C**
Loudon, Prof. James, Toronto, Can. (25). 1881. **B A**
Loughridge, Prof. R. H., South Carolina College, Columbia, S. C. (21). 1874. **E C**
Love, Edward G., School of Mines, Columbia College, New York, N. Y. (24). 1882. **C**
Lovering, Prof. Joseph, Harvard University, Cambridge, Mass. (2). 1875. **B A**
Lull, Edward P., Captain U. S. N., care Navy Dep't, Washington, D. C. (28). 1880. **E H**
Lupton, Prof. N. T., Auburn, Ala. (17). 1874. **C**

Lyle, David Alexander, Capt. of Ordnance U. S. A., Box 2253, Boston, Mass. (28). 1880. **D**

Lyman, Prof. Chester S., 88 Trumbull St., New Haven, Conn. (4). 1875. **A**

Lyman, Hon. Theodore, Brookline, Mass. (23). 1875. **F**

Lyon, Dr. Henry, 34 Monument Sq., Charlestown, Mass. (18). 1874.

McAdams, Wm., Alton, Ill. (27). 1885. **E H**

McCauley, Capt. C. A. H., Ass't Q. M., U. S. A., 321 Michigan Ave., Chicago, Ill. (29). 1881.

McGee, W. J., U. S. Geol. Survey, Washington, D. C. (27). 1882. **E**

McMurtrie, William, Univ. of Illinois, Champaign, Ill. (22). 1874. **C**

McNeill, Malcolm, Princeton, N. J. (32). 1885. **A**

McRae, Hamilton S., Supt. of Schools, Marion, Ind. (20). 1874. **H I**

Mabery, Prof. C. F., Case School of Applied Science, Cleveland, Ohio (29). 1881. **C**

Macfarlane, James, Towanda, Pa. (29). 1882. **E**

Mackintosh, James B., School of Mines, Columbia College, New York, N. Y. (27). 1883. **C B**

Macloskie, Prof. George, College of New Jersey, Princeton, N. J. (25). 1882. **F**

Mallery, Brevet Lieut. Col. Garrick, U. S. Army, Bureau of Ethnology, Washington, D. C. (26). 1879. **H**

Mann, B. Pickman. U. S. Department of Agriculture, Washington, D. C. (22). 1874. **I F**

Marcy, Oliver, LL.D., Evanston, Ill. (10). 1874. **E**

Marsh, Prof. O. C., Yale College, New Haven, Conn. (15). 1874. **F H**

Martin, Prof. Daniel S., 236 West 4th St., New York, N. Y. (23). 1879. **E F**

Martin, Prof. H. Newell, Johns Hopkins University, Baltimore, Md. (27). 1880. **F H**

Martin, Prof. Wm. J., Davidson College, N. C. (31). 1884. **C E**

Mason, Prof. Otis T., National Mus., Washington, D. C. (25). 1877. **H**

Mayer, Prof. A. M., South Orange, N. J. (19). 1874.

Meehan, Thomas, Germantown, Pa. (17). 1875 **F**

Mees, Carl Leo, Columbus, Ohio (24). 1876. **B C**

Mendenhall, Prof. T. C., U. S. Signal Service, Washington, D. C. (20). 1874. **B**

Merriam, C. Hart, M.D., Locust Grove, Lewis Co., N. Y. (33). 1885. **F**

Merriman, C. C., Rochester, N. Y. (29). 1880. **F**

Merriman, Prof. Mansfield, Lehigh Univ., Bethlehem, Pa. (32). 1885 **A D**

Metz, Charles L., M.D., Madisonville, Hamilton Co., Ohio (33). 1885. **H**

Michelson, A. A., Master U. S. N., 7 Rockwell St., Cleveland, O. (26). 1879. **B**

Minot, Dr. Charles Sedgwick, 25 Mt. Vernon St., Boston, Mass. (28). 1880. **F**

Minot, Francis, M.D., 65 Marlborough St., Boston, Mass. (39). 1884.

Mitchell, Miss Maria, Vassar College, Poughkeepsie, N. Y. (4). 1874.

Mixter, Prof. Wm. G., New Haven, Conn. (30). 1882. **C**
Moore, Prof. J. W., M.D., Lafayette College, Easton, Pa. (22). 1874. **B D A**
Morley, Prof. Edward W., 749 Republic St., Cleveland, Ohio (18). 1876. **C B E**
Morris, Rev. John G., Baltimore, Md. (12). 1874.
Morse, Prof. E. S., Salem, Mass. (18). 1874. **F H**
Morton, H., Stevens Institute Technology, Hoboken, N. J. (18). 1875. **B C**
Moses, Prof. Thos. F., Urbana Univ., Urbana, Ohio (25). 1883. **H F**
Munroe, Prof. C. E., U. S. Naval Academy, Annapolis, Md. (22). 1874. **C**
Murdock. J. B., Lieut. U. S. N., 24 Alaska St., Roxbury, Mass. (28). 1885. **B**
Murtfeldt, Miss Mary E., Kirkwood, Mo. (27). 1881. **F**

Nason, Prof. H. B., Rensselaer Polytechnic Institute, Troy, N. Y. (13). 1874. **C E**
Neale, Arthur T., Ph.D., New Brunswick, N. J. (29). 1882.
Nelson, Prof. A. B., Centre College, Danville, Ky. (30). 1882. **A B D**
Nelson, Prof. Edward T., Delaware, Delaware Co., Ohio (24). 1877. **E F**
Newberry, Prof. J. S., Columbia College, New York, N. Y. (5). 1875. **E F H I**
Newcomb, Prof. S., Navy Dep't, Washington, D. C. (13). 1874. **A B**
Newton, Hubert A., New Haven, Conn. (6). 1874. **A**
Nichols, E. L., Ph.D., Univ. of Kansas, Lawrence, Kansas (28). 1881. **B C**
Nichols, Prof. W. R., Mass. Inst. Technology, Boston, Mass. (18). 1875. **C**
Niles, Prof. W. H., Cambridge, Mass. (16). 1874.
Nipher, Prof. F. E., Washington Univ., St. Louis, Mo. (24). 1876. **B**
Norton, Lewis M., Ph.D., Mass. Institute of Technology, Boston, Mass. (29). 1884. **C**
Noyes, Wm. A., Ph.D., Univ. of Tenn., Knoxville, Tenn. (32). 1885. **C**

Oliver, Prof. James E., P. O. Box 1566, Ithaca, N. Y. (7). 1875. **A B I**
Oliver, Miss Mary E., Cascadilla Hotel, Ithaca, N. Y. (20). 1874.
Ordway, Prof. John M., Tulane Univ., New Orleans, La. (9). 1875. **C**
Orton, Prof. Edward, President Ohio Agricultural and Mechanical College, Columbus, Ohio (19). 1875. **E**
Osborn, Henry F., S.D., Garrisons, N. Y. (29). 1883.
Osborn, Herbert, Ames, Iowa (32). 1884. **F**
Osborne, J. W., 212 Delaware Ave. N. E., Washington, D. C. (22). 1874. **D C B**
Osler, Prof. William, McGill College, Montreal, Canada (28). 1881.
Owen, Dr. Richard, New Harmony, Ind. (20). 1874. **E**
Owens, Mrs. Mary E., 270 W. 7th St., Cincinnati, Ohio (30). 1885. **C**

Packard, Dr. A. S., 115 Angell St., Providence, R. I. (16). 1875.
Paine, Cyrus F., 242 East Ave., Rochester, N. Y. (12). 1874. **B A**

Paine, Nathaniel, Worcester, Mass. (18). 1874. **H**

Palfray, Hon. Charles W., Salem, Mass. (21). 1874.

Parke, John G., Lt. Col. Corps of Eng'rs, Bv't Maj. Gen. U. S. A., Office of Chief of Engineers, Washington, D. C. (29). 1881.

Parkhurst, Henry M., Law Stenographer, 25 Chambers St., New York, N. Y. (23). 1874. **A**

Paul, Prof. Henry M., U. S. Naval Observatory, Washington, D. C. (33). 1885. **A B**

Payne, Prof. Wm. W., Carleton College Observatory, Northfield, Minn. (30). 1883. **A**

Peabody, Selim H., Regent University of Illinois, Champaign, Ill. (17.) 1885. **D B F**

Peckham, S. F., Bristol, R. I. (18). 1875. **C B E**

Pedrick, Wm. R., Lawrence, Mass. (22). 1875.

Peet, Rev. Stephen D., Clinton, Wis. (24). 1881. **H**

Peirce, Prof. James M., Cambridge, Mass. (28). 1881. **A**

Penhallow, Prof. D. P., McGill College, Montreal, Can. (30). 1882. **F**

Perkins, Prof. George H., Burlington, Vt. (17). 1882. **H F E**

Peter, Dr. Robert, Kentucky Geol. Survey, Lexington, Ky. (29). 1881. **C**

Pettee, Prof. William H., Ann Arbor, Mich. (24). 1875. **E**

Phillips, A. W., New Haven, Conn. (24). 1879.

Phippen, Geo. D., Salem, Mass. (18). 1874. **F**

Pickering, Prof. E. C., Director of Observatory, Cambridge, Mass. (18). 1874. **A R**

Pickering, William H., Inst. Technology, Boston, Mass. (29). 1883. **B A**

Pike, Dr. William H., University College, Toronto, Can. (29). 1881.

Pilsbry, James C., Box 301, Washington, D. C. (28). 1882. **F H I**

Pinkney, Prof. John H., Smith College, Northampton, Mass. (25). 1885. **F H**

Platt, Frederick, Asst. Geologist, 2nd Geol. Survey of Pa., 715 Walnut St., Philadelphia, Pa. (29). 1882. **E**

Pl[illegible] (32). 1884. **E F**

Po[illegible] 25). 1879.

Po[illegible] D. C. [illegible] **F H**

Po[illegible] D. C. (29). [illegible] **F**

[illegible] **C**

[illegible] **A**

[illegible] **A K**

[illegible] **F**

[illegible]

Rauch, Dr. John H., Chicago, Ill. (11). 1875.
Raymond, Rossiter W., 17 Burling Slip, New York, N. Y. (15). 1875. **E I**
Redfield, J. H., care A. Whitney & Sons, Philadelphia, Pa. (1). 1874. **F**
Reed, E. Baynes, London, Ontario, Can. (27). 1882.
Rees, Prof. John K., Columbia College, New York, N. Y. (26). 1878. **A E B**
Remsen, Prof. Ira, Johns Hopkins Univ., Baltimore, Md. (22). 1875. **C**
Rice, John M., U. S. Naval Academy, Annapolis, Md. (25). 1881. **A D**
Rice, Prof. Wm. North, Wesleyan University, Middletown, Conn. (18). 1874. **E F**
Richards, Prof. Charles B., 43 Elm St., New Haven, Conn. (33). 1885. **D**
Richards, Prof. Robert H., Mass. Inst. Tech., Boston, Mass. (22). 1875. **D**
Richards, Mrs. Robert H., Prof. Mass. Inst. of Tech., Boston, Mass. (23). 1878. **C**
Richardson, Clifford, Dep't of Agric., Washington, D. C. (30). 1884. **C**
Ricketts, Pierre de Peyster, Ph.D., School of Mines, Columbia College, New York, N. Y. (26). 1880. **C D E**
Riley, Prof. C. V., U. S. Entomologist, 1700 13th St. N. W., Washington, D. C. (17). 1874. **F H I**
Ritchie, E. S., 87 Franklin St., Boston, Mass. (10). 1877. **B**
Robinson, Prof. S. W., Univ. of Ohio, Columbus, Ohio (30). 1883. **D B A**
Rockwell, Gen. Alfred P., 3 Fairfield St., Boston, Mass. (10). 1882. **E**
Rockwell, Chas. H., Box 293, Tarrytown, N. Y. (28). 1883. **A D**
Rockwood, Prof. Charles G., jr., College of New Jersey, Princeton, N. J. (20). 1874. **A E B D**
Rogers, Fairman, 202 West Rittenhouse Square, Philadelphia, Pa. (11). 1874.
Rogers, W. A., Ass't Prof. Harvard College Observatory, Cambridge, Mass. (15). 1875. **A B D F**
Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879. **E**
Rood, Prof. O. N., Columbia College, New York, N. Y. (14). 1875. **B**
Rosenspitz, Dr. Alexander, Rabbi, Lock Box 688, Jacksonville, Fla. (26). 1883. **F E H**
Ross, Waldo O., 189 Devonshire St., Boston, Mass. (29). 1882.
Rowland, Prof. Henry A., Baltimore, Md. (29). 1880.
Runkle, Prof. J. D., Mass. Inst. of Tech., Boston, Mass. (2). 1875. **A D**
Rutherford, Lewis M., 175 Second Ave., New York, N. Y. (13). 1875.

Sadtler, Prof. Saml. P., Univ. of Pa., Philadelphia, Pa. (22). 1875. **C**
Safford, Dr. James M., Nashville, Tenn. (6). 1875. **E C F**
Salmon, Daniel E., Dep't of Agric., Washington, D. C. (31). 1885. **F**
Sampson, Comander W. T., U. S. N., Torpedo Station, Newport, R. I. (25). 1881. **B A**
Saunders, William, London, Ontario, Canada (17). 1874. **F**
Schanck, Prof. J. Stillwell, Princeton, New Jersey (4). 1882. **C B H**
Schott, Charles A., U. S. Coast and Geodetic Survey Office, Washington, D. C. (8). 1874. **A**

Schweitzer, Prof. Paul, State University of Missouri, Columbia, Mo. (24). 1877. **C B**

SCUDDER, SAMUEL H., Cambridge, Mass. (13). 1874. **F**

Seaman, W. H., Microscopist, 1424 11th St. N. W., Washington, D. C. (23). 1874. **C F**

Seller, Carl, M.D., 1346 Spruce St., Philadelphia, Pa. (29). 1882. **F B**

Sewall, Prof. Henry, Univ. of Mich., Ann Arbor, Mich. (34). 1885. **F**

Sharples, Stephen P., 13 Broad St., Boston, Mass. (29). 1884. **C**

Sheafer, P. W., Pottsville, Pa. (4). 1879. **E**

Silas, Solomon, M.D., Schoharie, Schoharie Co., N. Y. (10). 1874.

Sigsbee, Chas. D., Comd'r U. S. N., care of Navy Dep't, Washington, D. C. (28). 1882. **D E**

Sill, Hon. Elisha N., Cuyahoga Falls, Ohio (6). 1874.

Silliman, Prof. Justus M., Lafayette College, Easton, Pa. (19). 1874. **D E**

Skinner, Joseph J., Ithaca, N. Y. (23). 1880. **B**

Smiley, Charles W., U. S. Fish Commission, Washington, D. C. (28). 1883. **I**

Smith, Edwin, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (30). 1882. **A B**

Smith, Prof. Eugene A., University of Alabama, Tuscaloosa, Ala. (20). 1877. **E C**

Smith, Prof. Francis H., University of Virginia, Charlottesville, Va. (26). 1880. **B A**

Smith, John B., National Museum, Washington, D. C. (32). 1884. **F**

SMITH, QUINTUS C., M.D., No. 704 Congress Ave., Austin, Texas (26). 1881. **F**

Smith, Prof. S. I., Yale College, New Haven, Conn. (18). 1875. **F**

Smock, Prof. John Conover, New York State Museum, Albany, N. Y. (23). 1879. **E**

Snow, Prof. F. H., Lawrence, Kan. (29). 1881. **F E**

Snyder, Prof. Monroe B., High School Observatory, Philadelphia, Pa. (24). 1882. **A B**

Spencer, Prof. J. William, University of Missouri, Columbia, Mo. (28). 1882. **K**

Spencer, Dr. Chas., Box 339, Cleveland, Ohio (24). 1882. **C**

Stanley, J. B., Mason's Depot, Chautauqua Co., N. Y. 1882.

Stanton, R. [illegible] 1884.

Stanton, R. B., Chief Naval Ordnance Bureau, Navy Department, Washington, D. C. (18). 1884. **F**

Stearns, D. Lewis, B., Peabody Institute, Baltimore, Md. (7). 1884. **I**

Stebbins, W. [illegible] N. Y. 1884. **E K**

Stebbins, [illegible] N. Y. [illegible] Baltimore, Md. (24). 1884. **F**

Stevens, W. [illegible] Brooklyn, N. Y. (20). 1882. **B A C**

Stevenson, James, Ass't Ethnologist, Washington, D. C. (29). 1885. **H**
Stockwell, John N., 1008 Case Avenue, Cleveland, Ohio (18). 1875. **A**
Stone, George H., Colorado Springs, Col. (29). 1882. **E F**
Stone, Mrs. Leander, 3417 Indiana Avenue, Chicago, Ill. (22). 1874. **F E**
Stone, Ormond, Director Leander McCormick Observatory, University of Virginia, Va. (24). 1876. **A**
Storrs, Henry E., Jacksonville, Ill. (20). 1874. **C E**
Story, Wm. E., Johns Hopkins Univ., Baltimore, Md. (29). 1881. **A**
Stowell, Prof. T. B., Cortland, N. Y. (28). 1885. **F**
Stringham, Prof. Irving, Univ. of Cal., Berkeley, Cal. (33). 1885. **A**
Stuart, Prof. A. P. S., Lincoln, Nebraska (21). 1874. **C**
Sturtevant, E. Lewis, M.D., Geneva, N. Y. (29). 1882. **F**
Swift, Lewis, Ph.D., Rochester, N. Y. (29). 1882. **A**

Tainter, Sumner, 2020 F St. N. W., Washington, D. C. (29). 1881. **B D A**
Taylor, Thos., M.D., Dep't of Agric., Washington, D. C. (29). 1885. **F C**
Taylor, William B., Smithsonian Institution, Washington, D. C. (29). 1881. **B A**
Terry, Prof. N. M., U. S. Naval Academy, Annapolis, Md. (23). 1874. **B**
Thomas, Benj. F., Ph.D., State Univ., Columbus, Ohio (29). 1882. **B A**
Thomas, Prof. Cyrus, Carbondale, Ill. (30). 1882.
Thomson, Wm., M.D., 1426 Walnut St., Philadelphia, Pa. (33). 1885. **B**
Thurston, Prof. R. H., Sibley College, Cornell University, Ithaca, N. Y. (23). 1875. **D**
Todd, Prof. David P., Director Lawrence Observatory, Amherst College, Amherst, Mass. (27). 1881. **A B D**
Townshend, Prof. N. S., Ohio State Univ., Columbus, Ohio (17). 1881. **F H**
Tracy, Sam'l M., Columbia, Boone Co., Mo. (27). 1881. **F**
Trembley, J. B., M.D., 952 8th St., Oakland, Alameda Co., Cal. (17). 1880. **B F**
Trowbridge, Prof. John, Harvard University, Cambridge, Mass. (25). 1876.
Trowbridge, Prof. W. P., New Haven, Conn. (10). 1874. **D**
True, Fred W., U. S. National Museum, Washington, D.C. (28). 1882. **F**
Trumbull, Dr. J. Hammond, Hartford, Conn. (29). 1882. **H**
Tuttle, Prof. Albert H., State University, Columbus, Ohio (17). 1874. **F**

Uhler, Philip R., 218 W. Hoffman St., Baltimore, Md. (19). 1874. **F E**
Underwood, Prof. Lucien M., 214 East Genesee St., Syracuse, N. Y. (33). 1885. **F**
Upham, Warren, 21 Newbury St., Somerville, Mass. (25). 1880. **E**
Upton, Winslow, Brown Univ., Providence, R. I. (29). 1883. **A**

Van der Weyde, P. H., M.D., Box 3619, New York, N. Y. (17). 1874. **B**
Van Dyck, Prof. Francis Cuyler, New Brunswick, N. J. (28). 1882. **B C F**
Van Vleck, Prof. John M., Middletown, Conn. (23). 1875. **A**

Verrill, Prof. A. E., Yale College, New Haven, Conn. (16). 1875. **F E**
Vogdes, A. W., 1st Lt. 5th Art'y U. S. A., The Military Service Inst., Governor's Island, N. Y. (32). 1885. **E F**

Wachsmuth, Charles, 111 Marietta St., Burlington, Iowa (30). 1884. **E F**
Wadsworth, M. Edward, Ph D., Colby University, Waterville, Me. (23). 1874. **E**
Walcott, Charles D., Nat'l Museum, Washington, D. C. (25). 1882. **E F**
Waldo, Leonard, S.D., Yale College Observatory, New Haven, Conn. (28). 1880. **A**
Walker, J. R., D.D.S., Bay Saint Louis, Hancock Co., Miss. (19). 1874. **E F H D B**
Wallace, Wm., Ansonia, Conn. (28). 1882.
WALLER, E., School of Mines, Columbia College, New York, N. Y. (23). 1874.
Walling, H. F., 98 Trowbridge St., Cambridge, Mass. (16). 1874. **E D A B**
Walmsley, W. H., 1016 Chestnut St., Philadelphia, Pa. (28). 1883. **F**
Ward, Prof. Henry A., Rochester, N. Y. (13). 1875. **F E H**
Ward, Lester F., U. S. Geological Survey, Washington, D. C. (26). 1879. **E F**
Ward, Dr. R. H., 53 Fourth St., Troy, N. Y. (17). 1874. **F**
Warder, Prof. Robert B., Lafayette, Ind. (19). 1881. **C B**
WARNER, JAMES D., 199 Baltic St., Brooklyn, N. Y. (18). 1874. **A B**
Warren, Cyrus M., Brookline, Mass. (29). 1882. **C**
Warren, Prof. S. Edward, Newton, Mass. (17). 1875. **A–I**
Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22). 1875. **F**
WATSON, PROF. WM., 107 Marlborough St., Boston, Mass. (12). 1884.
Wead, Prof. Charles K., Univ. of Mich., Ann Arbor, Mich. (23). 1880. **B**
Webb, Prof. J. Burkitt, Stevens Inst., Hoboken, N. J. (31). 1883. **D B A**
Webster, Prof. N. B., Principal Webster Inst., Norfolk, Va. (7). 1874. **B C E**
Wells, Daniel H., Hartford, Conn. (18). 1875. **A I**
Westcott, O. S., Maywood, Cook Co., Ill. (21). 1874. **H F A**
Wheatland, Dr. Henry, President Essex Inst., Salem, Mass. (1). 1874.
Wheeler, Prof. C. Gilbert, 81 Clark St., Chicago, Ill. (18). 1883. **C E**
Wheeler, Capt. Geo. M., U. S. Engineers, Lock Box 93, Washington, D. C. (25). 1879.
Wheeler, Orlando B., 1415 Washington Ave., St. Louis, Mo. (24). 1882. **A D**
Wheildon, W. W., Box 229, Concord, Mass. (13). 1874. **B E**
White, Prof. C. A., Le Droit Park, Washington, D. C. (17). 1875. **E F**
White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29). 1885. **C**
White, Prof. I. C., Univ. of W. Va., Morgantown, W. Va. (25). 1882. **E**
Whitfield, R. P., American Museum Natural History, 77th St. & 8th Avenue, New York, N. Y. (18). 1874. **E F H**
Whiting, Miss Sarah F., Wellesley College, Wellesley, Mass. (31). 1883. **B A**

Whitman, Prof. Frank P., Rensselaer Polytechnic Inst., Troy, N. Y. (33). 1885.
Whitney, Solon F., Watertown, Mass. (20). 1874.
Whittlesey, Col. Charles, 1305 Euclid Ave., Cleveland, Ohio (1). 1875. **E**
Wilber, G. M., Pine Plains, N. Y. (19). 1874. **F H**
Wilbur, A. B., Port Jervis, Orange Co., N. Y. (23). 1874.
Wilder, Prof. Burt G., Cornell University, Ithaca, N. Y. (22). 1875. **F**
Wiley, Prof. Harvey W., Dep't of Agric., Washington, D.C. (21). 1874. **C**
Williams, Charles H., M.D., 15 Arlington St., Boston, Mass. (22). 1874.
Williams, Henry Shaler, Cornell Univ., Ithaca, N. Y. (18). 1882. **E F**
Williams, Prof. Henry W., 15 Arlington St., Boston, Mass. (11). 1874. **H F**
Williams, Prof. S. G., Cornell Univ., Ithaca, N. Y. (33). 1885. **E**
Wilson, Prof. Daniel, President University College, 117 Bloor St., Toronto, Canada (25). 1876. **H E**
Wilson, H. C., Cincinnati Observatory, Mt. Lookout, Hamilton Co., Ohio (30). 1885. **A**
Winchell, Prof. Alex., Ann Arbor, Mich. (3). 1875. **E**
Winchell, Prof. N. H., Univ. of Minnesota, Minneapolis, Minn. (19). 1874. **E H**
Winlock, Wm. C., U. S. N. Observ., Washington, D. C. (33). 1885. **A B**
Woerd, Chas. V., Am. Watch Co., Waltham, Mass. (29). 1881. **D A**
Wood, Prof. De Volson, Hoboken, N. J. (29). 1881.
Woodbury, C. J. H., 31 Milk St., Boston, Mass. (29). 1884. **D**
Woodward, Prof. Calvin M., 1761 Missouri Ave., St. Louis, Mo. (32). 1884. **D**
Woodward, R. S., care of U. S. Geol. Survey, Washington, D. C. (33). 1885. **A B D**
Wormley, T. G., Univ. of Pennsylvania, Philadelphia, Pa. (20). 1878.
Worthen, A. H., Springfield, Ill. (5). 1874. **E**
Wright, Prof. Albert A., Oberlin College, Oberlin, Ohio (24). 1880. **E F**
Wright, Prof. Arthur W., Yale Coll., New Haven, Conn. (14). 1874. **A B**
Wright, Rev. Geo. F., Oberlin College, Oberlin, Ohio (29). 1882. **E**
Würtele, Rev. Louis C., Acton Vale, Province of Quebec, Can. (11). 1875. **E**
Wyckoff, Wm. C., 44 Howard St., New York, N. Y. (20). 1874.
Wylie, Prof. Theoph. A., Indiana Univ., Bloomington, Ind. (20). 1874.

Youmans, Prof. Edward L., New York, N. Y. (6). 1874.
Young, C. A., Prof. of Astronomy, College of New Jersey, Princeton N. J. (18). 1874. **A B D**

Zentmayer, Joseph, 147 S. Fourth St., Philadelphia, Pa. (29). 1882. **F**

[606 FELLOWS.]

JULY 1, 1886, TOTAL NUMBER OF MEMBERS OF THE ASSOCIATION, 1956.

DECEASED MEMBERS.

[Information respecting omissions in this list, and the date of birth and of decease of any of the former members, is requested by the Permanent Secretary.]

Abbe, George W., New York, N. Y. (23). Died Sept. 25, 1879.

Abert, J. J., Washington, D. C. (1). Born in 1785. Died January 27, 1863.

Adams, C. B., Amherst, Mass. (1). Born January 11, 1814. Died Jan'y 19, 1853.

Adams, Edwin F., Charlestown, Mass. (18).

Adams, Samuel, Jacksonville, Ill. (18). Born Dec. 19, 1806. Died April 29, 1877.

Agassiz, Louis, Cambridge, Mass. (1). Born May 28, 1807. Died Dec. 14, 1873.

Ainsworth, J. G., Barry, Mass. (14).

Alexander, Stephen, Princeton, N. J. (1). Born Sept. 1, 1806. Died June 25, 1883.

Allen, Thomas, St. Louis, Mo. (27). Died April 8, 1882.

Allen, Zachariah, Providence, R. I. (1). Died March 17, 1882.

Allston, R. F. W., Georgetown, S. C. (3). Born April 21, 1801. Died April 7, 1864.

Alvord, Benjamin, Washington, D. C. (17). Died Oct. 16, 1884, at the age of 71.

Ames, M. P., Springfield, Mass. (1). Born in 1803. Died April 23, 1847.

Andrews, Ebenezer B., Lancaster, Ohio (7). Died Aug. 21, 1880, aged 59.

Anthony, Charles H., Albany, N. Y. (6). Died in 1874.

Appleton, Nathan, Boston, Mass. (1). Born Oct. 6, 1779. Died July 14, 1861.

Armstrong, John W., Fredonia, N. Y. (24).

Atwater, Mrs. S. T., Chicago, Ill. (17). Born Aug. 8, 1812. Died April 11, 1878.

Aufrecht, Louis, Cincinnati, Ohio (30).

Bache, Alexander D., Washington, D. C. (1). Born July 19, 1806. Died Feb. 17, 1867.

Bache, Franklin, Philadelphia, Pa. (1). Born Oct. 25, 1792. Died March 19, 1864.

Bailey, Jacob W., West Point, N. Y. (1). Born April 29, 1811. Died Feb. 26, 1857.

Bardwell, F. W., Lawrence, Kan. (13). Died in 1878.

Barnard, John G., New York, N. Y. (14). Died May 14, 1882.
Barrett, Moses, Milwaukee, Wis. (21). Died in 1873.
Barry, Redmond, Melbourne, Australia (25).
Bassnett, Thomas, Jacksonville, Fla. (8). Died Feb. 16, 1886, aged 79 years.
Beck, C. F., Philadelphia, Pa. (1).
Beck, Lewis C., New Brunswick, N. J. (1). Born Oct. 4, 1798. Died April 21, 1853.
Beck, T. Romeyn, Albany, N. Y. (1). Born Aug. 11, 1791. Died Nov. 19, 1855.
Beckwith, Henry C., Coleman's Station, N. Y. (29). Died July 12, 1885.
Belfrage, G. W., Clifton, Texas (29). Died Dec. 7, 1882.
Belt, Thomas, London, Eng. (27). Died Sept. 8, 1878.
Benedict, George W., Burlington, Vt. (16). Born Jan. 11, 1796. Died in 1871.
Bicknell, Edwin, Boston, Mass. (18). Born in 1830. Died March 19, 1877.
Binney, Amos, Boston, Mass. (1). Born Oct. 18, 1803. Died Feb. 18, 1847.
Binney, John, Boston, Mass. (3).
Blackie, Geo. S., Nashville, Tenn. (26).
Blair, Henry W., Washington, D. C., (26). Died Dec. 15, 1884.
Blake, Homer C., New York, N. Y. (28). Born Feb. 1, 1822.
Blanding, William, ———, R. I. (1).
Blatchford, Thomas W., Troy, N. Y. (6).
Blatchley, Miss S. L., New Haven, Conn. (19). Died March 13, 1873.
Boadle, John, Haddonfield, N. J. (20). Born in 1805. Died in July, 1878.
Bomford, George, Washington, D. C. (1). Born 1780. Died March 25, 1848.
Bowron, James, South Pittsburg, Tenn. (26). Died in Dec., 1877.
Bradley, Leverette, Jersey City, N. J. (15). Died in 1875.
Braithwaite, Jos., Chambly, C. W. (11).
Briggs, Albert D., Springfield, Mass. (13). Died Feb. 20, 1881.
Briggs, Robert, Philadelphia, Pa. (29). Born May 18, 1822. Died July 24, 1882.
Brigham, Charles H., Ann Arbor, Mich. (17). Born July 27, 1820. Died in Jan., 1879.
Brown, Andrew, Natchez, Miss. (1).
Brown, Horace, Salem, Mass. (27). Died in July, 1883.
Bull, John, Washington, D. C. (31). Born Aug. 1, 1819. Died June 9, 1884.
Burbank, L. S., Woburn, Mass. (18).
Burke, Joseph Chester, Middletown, Conn. (29). Died in 1885.
Burnap, G. W., Baltimore, Md. (12). Born Nov. 30, 1802. Died Sept. 8, 1859.
Burnett, Waldo I., Boston, Mass. (1). Died July 1, 1854, aged 27.
Butler, Thomas B., Norwalk, Conn. (10). Born Aug. 22, 1806. Died June 8, 1873.

Cairns, F. A., New York, N. Y. (27). Died in 1879.
Campbell, Mrs. Mary H., Crawfordsville, Ind. (22). Died Feb. 27, 1882.
Carpenter, Thornton, Camden, S. C. (7).
Carpenter, William M., New Orleans, La. (1).
Case, Leonard, Cleveland, Ohio (15). Born June 27, 1820. Died Jan. 5, 1880.
Case, William, Cleveland, Ohio (6).
Caswell, Alexis, Providence, R. I. (2). Born Jan. 29, 1799. Died Jan. 8, 1877.
Chadbourne, Paul Ansel, Amherst, Mass. (10). Born Oct. 21, 1823. Died Feb. 23, 1883.
Chapman, N., Philadelphia, Pa. (1). Born May 28, 1780. Died July 1, 1853.
Chase, Stephen, Hanover, N. H. (2). Born in 1813. Died Aug. 5, 1851.
Chauvenet, William, St. Louis, Mo. (1). Born May 24, 1819. Died Dec. 13, 1870.
Cheesman, Louis M., Hartford, Conn. (32). Died in Jan. 1885, aged 27 years.
Cheney, Miss Margaret S., Jamaica Plain, Mass. (29). Died in 1882.
Clapp, Asahel, New Albany, Ind. (1). Born Oct. 5, 1792. Died Dec. 15, 1862.
Clark, Henry James, Cambridge, Mass. (13). Died July 1, 1873, aged 47.
Clark, Joseph, Cincinnati, Ohio (5).
Clarke, A. B., Holyoke, Mass. (13).
Cleaveland, C. H., Cincinnati, Ohio (9).
Cleveland, A. B., Cambridge, Mass. (2).
Coffin, James H., Easton, Pa. (1). Born Sept. 6, 1806. Died Feb. 6, 1873.
Cole, Thomas, Salem, Mass. (1). Born Dec. 24, 1779. Died June 24, 1852.
Coleman, Henry, Boston, Mass. (1).
Collins, Frederick, Washington, D. C. (28). Born Dec. 5, 1842. Died Oct. 27, 1881.
Conrad, Timothy Abbott, Philadelphia, Pa. (1). Born in August, 1803. Died August 9, 1877.
Cooke, Caleb, Salem, Mass. (18). Born Feb. 15, 1838. Died June 5, 1880.
Cooper, William, Hoboken, N. J. (9). Died in 1864.
Copes, Joseph S., New Orleans, La. (11). Born Dec. 9, 1811. Died March 1, 1885.
Corning, Erastus, Albany, N. Y. (6). Born Dec. 14, 1794. Died April 9, 1872.
Costin, M. P., Fordham, N. Y. (30). Died June 8, 1884.
Couper, James Hamilton, Darien, Ga. (1). Born March 5, 1794. Died July 3, 1866.
Cramp, J. M., Wolfville, N. S. (11). Born July 25, 1796. Died Dec. 6, 1881.
Crehore, John D., Cleveland, Ohio (24).
Crocker, Charles F., Lawrence, Mass. (22). Died in July, 1881.
Crosby, Alpheus, Salem, Mass. (10). Born Oct. 18, 1810. Died April 17, 1874.

Crosby, Thomas R., Hanover, N. H. (18). Born Oct. 22, 1816. Died March 1, 1872.
Croswell, Edwin, Albany, N. Y. (6). Born in May, 1797. Died June 18, 1871.
Crow, Wayman, St. Louis, Mo. (27). Born March 7, 1808. Died May 10, 1885.
Curry, W. F., Geneva, N. Y. (11).
Curtis, Josiah, Washington, D. C. (18). Died Aug. 1, 1883.

Dalrymple, E. A., Baltimore, Md. (11). Died Oct. 30, 1881.
Dayton, Edwin A., Madrid, N. Y. (7). Born in 1827. Died June 24, 1873.
Dean, Amos, Albany, N. Y. (6). Born Jan. 16, 1803. Died Jan. 26, 1868.
Dearborn, George H. A. S., Roxbury, Mass. (1).
Dekay, James E., New York, N. Y. (1). Born in 1792. Died Nov. 21, 1851.
DeLaski, John, Carver's Harbor, Me. (18).
Devereux, J. H., Cleveland, Ohio (18). Died March 17, 1886.
Dewey, Chester, Rochester, N. Y. (1). Born Oct. 25, 1781. Died Dec. 15, 1867.
Dexter, G. M., Boston, Mass. (11).
Dillingham, W. A. P., Augusta, Me. (17).
Dimmick, L. N., Santa Barbara, Cal. (29). Died May 31, 1884.
Dixwell, Geo. B., Boston, Mass. (29). Died April, 1885.
Doggett, Mrs. Kate N., Chicago, Ill. (17). Died March 12, 1884.
Doggett, Wm. E., Chicago, Ill. (17). Born Nov. 20, 1820. Died in 1876.
Doolittle, L., Lenoxville, C. E. (11). Died in 1862.
Dorr, E. P., Buffalo, N. Y. (15). Died March 28, 1881.
Draper, Henry, New York, N. Y. (28).
Ducatel, J. T., Baltimore, Md. (1).
Duffield, George, Detroit, Mich. (10). Born July 4, 1794. Died June 26, 1869.
Dumont, A. H., Newport, R. I. (14).
Duncan, Lucius C., New Orleans, La. (10). Died Aug. 9, 1855, aged 54.
Dunn, R. P., Providence, R. I. (14).

Easton, Norman, Fall River, Mass. (14). Died Dec. 21, 1872.
Eaton, James H., Beloit, Wis. (17). Died Jan. 5, 1877.
Elsberg, Louis, New York, N. Y. (23). Died Feb. 19, 1885, aged 48 years.
Elwyn, Alfred L., Philadelphia, Pa. (1). Died March 15, 1884.
Ely, Charles Arthur, Elyria, Ohio (4).
Emerson, Geo. B., Boston, Mass. (1). Born Sept. 12, 1797. Died March 4, 1881.
Emmons, Ebenezer, Williamstown, Mass. (1). Born May 16, 1799. Died October 1, 1863.
Engelmann, George, St. Louis, Mo. (1). Born Feb. 2, 1809. Died Feb. 4, 1884.
Engstrom, A. B., Burlington, N. J. (1).

Eustis, Henry L., Cambridge, Mass. (2). Born Feb. 1, 1819. Died Jan. 11, 1885.

Everett, Edward, Boston, Mass. (2). Born April 11, 1794. Died Jan. 15, 1865.

Ewing, Thomas, Lancaster, Ohio (5). Born Dec. 28, 1789. Died Oct. 26, 1871.

Faries, R. J., Wauwatosa, Wis. (21). Died May 31, 1878.

Farquharson, Robert James, Des Moines, Iowa (24). Died Sept. 6, 1884.

Ferris, Isaac, New York, N. Y. (6). Born Oct. 9, 1798. Died June 16, 1873.

Feuchtwanger, Lewis, New York, N. Y. (11). Died June 25, 1876.

Fillmore, Millard, Buffalo, N. Y. (7). Born Jan. 7, 1800. Died March 8, 1874.

Fisher, Mark, Trenton, N. J. (10).

Fitch, Alexander, Hartford, Conn. (1). Born March 25, 1799. Died Jan. 20, 1859.

Fitch, O. H., Ashtabula, Ohio (7). Died Sept. 17, 1882, in his 80th year.

Forbush, E. B., Buffalo, N. Y. (15).

Force, Peter, Washington, D. C. (4). Born Nov. 26, 1790. Died Jan. 23, 1868.

Ford, A. C., Nashville, Tenn. (26).

Forshey, Caleb G., New Orleans, La. (21). Died in Aug., 1881.

Foster, John W., Chicago, Ill. (1). Born March 4, 1815. Died June 29, 1873.

Foucon, Felix, Madison, Wis. (18).

Fowle, Wm. B., Boston, Mass. (1). Born Oct. 17, 1795. Died Feb. 6, 1865.

Fox, Charles, Grosse Ile, Mich. (7).

Frazer, John F., Philadelphia, Pa. (1). Born July 8, 1812. Died Oct. 12, 1872.

French, J. W., West Point, N. Y. (11).

Garber, A. P., Columbia, Pa. (29). Died Aug. 26, 1881.

Gavit, John E., New York, N. Y. (1).

Gay, Martin, Boston, Mass. (1). Died Jan. 12, 1850, aged 46.

Gibbon, J. H., Charlotte, N. C. (3).

Gillespie, W. M., Schenectady, N. Y. (10). Born in 1816. Died Jan'y 1, 1868.

Gilmor, Robert, Baltimore, Md. (1).

Glazier, W. W., Key West, Fla. (29). Died Dec. 11, 1880.

Goldmark, J., New York, N. Y. (29). Died in April, 1882.

Gould, Augustus A., Boston, Mass. (11). Born April 23, 1805. Died Sept. 15, 1866.

Gould, B. A., Boston, Mass. (2). Born June 15, 1787. Died Oct. 24, 1859.

Graham, James D., Washington, D. C. (1). Born in 1799. Died Dec. 28, 1865.

Gray, Alonzo, Brooklyn, N. Y. (13). Born in 1808. Died March 10, 1860.
Gray, James H., Springfield, Mass. (6).
Greene, Benjamin D., Boston, Mass. (1). Died Oct. 14, 1862, aged 68.
Greene, Everett W., Madison, N. J. (10). Died in 1864.
Greene, Samuel, Woonsocket, R. I. (9). Died in 1868.
Greer, James, Dayton, Ohio (20). Died in Feb., 1874.
Griffith, Robert E., Philadelphia, Pa. (1).
Griswold, John A., Troy, N. Y. (19). Born in 1822. Died Oct. 31, 1872.
Guest, William E., Ogdensburg, N. Y. (6).
Guyot, Arnold, Princeton, N. J. (1). Born Sept. 5, 1809. Died Feb. 8, 1884.

Hackley, Charles W., New York, N. Y. (4). Born March 9, 1809. Died January 10, 1861.
Hadley, George, Buffalo, N. Y. (6). Born June, 1813. Died Oct. 16, 1877.
Haldeman, S. S., Chickies, Pa. (1). Died Sept. 10, 1880, aged 68.
Hale, Enoch, Boston, Mass. (1). Born Jan. 29, 1790. Died Nov. 12, 1848.
Hance, Ebenezer, Fallsington P. O., Pa. (7). Died in 1876.
Hare, Robert, Philadelphia, Pa. (1). Born Jan. 17, 1781. Died May 15, 1858.
Harlan, Joseph G., Haverford, Pa. (8).
Harlan, Richard, Philadelphia, Pa. (1).
Harris, Thaddeus W., Cambridge, Mass. (1). Born Nov. 12, 1795. Died Jan. 16, 1856.
Harrison, A. M., Plymouth, Mass. (29).
Harrison, Jos., jr., Philadelphia, Pa. (12).
Hart, Simeon, Farmington, Conn. (1). Died April 20, 1853, aged 57.
Hartt, Charles F., Ithaca, N. Y. (18). Born in 1840. Died March 18, 1878.
Haven, Joseph, Chicago, Ill. (17). Born Jan. 4, 1816. Died May 23, 1874.
Hawes, George W., Washington, D. C. (23). Born Dec. 31, 1848. Died June 22, 1882.
Hayden, H. H., Baltimore, Md. (1).
Hayes, George E., Buffalo, N. Y. (15).
Hayward, James, Boston, Mass. (1). Died July 27, 1866, aged 80.
Hempstead, G. S. B., Portsmouth, Ohio (29). Died July 9, 1883, in his 89th year.
Henry, Joseph, Washington, D. C. (1). Born Dec. 17, 1797. Died May 13, 1878.
Hickox, S. V. R., Chicago, Ill. (17). Died in 1872.
Hilgard, Theo. C., St. Louis, Mo. (17). Born Feb. 28, 1828. Died Mch. 5, 1875.
Hill, Walter N., Chester, Pa. (29). Born April 15, 1846. Died March 29, 1884.
Hincks, William, Toronto, C. W. (11).
Hitchcock, Edward, Amherst, Mass. (1). Born May 24, 1793. Died Feb. 27, 1864.
Hodgson, W. B., Savannah, Ga. (10). Born 1815.

Holbrook, John E., Charleston, S. C. (1). Born Dec. 31, 1796. Died Sept. 8, 1871.
Holman, Mrs. S. W., Boston, Mass. (29). Died May 5, 1885.
Hopkins, Albert, Williamstown, Mass. (19). Born July 14, 1807. Died May 25, 1872.
Hopkins, James G., Ogdensburg, N. Y. (10). Died in 1860.
Hopkins, T. O., Williamsville, N. Y. (10). Died in 1866.
Hopkins, Wm., Lima, N. Y. (5.) Died in March, 1867.
Hoppock, A. E., Hastings-on-Hudson, N. Y. (29).
Horton, C. V. R., Chaumont, N. Y. (10). Died in 1862.
Horton, William, Craigville, N. Y. (1).
Hosford, Benj. F., Haverhill, Mass. (13). Died in 1864.
Hough, Franklin B., Lowville, N. Y. (4). Born 1822. Died June 11, 1885.
Houghton, Douglas, Detroit, Mich. (1). Born Sept. 21, 1809. Died Oct. 13, 1845.
Hovey, Edmund O., Crawfordsville, Ind. (20). Born July 15, 1801. Died March 10, 1877.
Howland, Theodore, Buffalo, N. Y. (15).
Hubbert, James, Richmond, Province of Quebec (16). Died in 1868.
Hunt, Edward B., Washington, D. C. (2). Born June 15, 1822. Died Oct. 2, 1863.
Hunt, Freeman, New York, N. Y. (11). Born March 21, 1804. Died March 2, 1858.

Ives, Moses B., Providence, R. I. (9). Died in 1857.
Ives, Thomas P., Providence, R. I. (10).

Jackson, Charles T., Boston, Mass. (1). Born June 21, 1805. Died Aug. 29, 1880.
James, Thomas Potts, Cambridge, Mass. (22). Born Sept. 1, 1803. Died Feb. 22, 1882.
Johnson, Walter R., Washington, D. C. (1). Born June 21, 1794. Died April 26, 1852.
Johnson, William Schuyler, Washington, D. C. (31). Born Sept. 20, 1859. Died Oct. 6, 1883.
Jones, Catesby A. R., Washington, D. C. (8).
Jones, Henry A., Portland, Me. (29). Died Sept. 3, 1883.
Jones, James H., Boston, Mass. (28).

Kedzie, W. K., Oberlin, Ohio (25).
Keely, George W., Waterville, Me. (1). Died in 1878.
Keep, N. C., Boston, Mass. (13). Died in March, 1875.
Kennicott, Robert, West Northfield, Ill. (12). Born Nov. 13, 1835. Died in 1866.
Kerr, Washington Caruthers, Raleigh, N. C. (10). Died Aug. 9, 1885, aged 56 years.

Kidder, Henry Purkitt, Boston, Mass. (29). Born Jan. 18, 1823. Died in 1886.
King, Mitchell, Charleston, S. C. (3). Born June 8, 1783. Died in 1862.
Kite, Thomas, Cincinnati, Ohio (5). Died Feb. 6, 1884.
Klippart, John H., Columbus, Ohio (17). Died October, 1878.
Knickerbocker, Charles, Chicago, Ill. (17). Died in 1873.
Knight, J. B., Philadelphia, Pa. (21). Died March 10, 1879.

Lacklan, R., Cincinnati, Ohio (11).
Lapham, Increase A., Milwaukee, Wis. (3). Born March 7, 1811. Died Sept. 14, 1875.
LaRoche, R., Philadelphia, Pa. (12).
Lasel, Edward, Williamstown, Mass. (1). Born Jan. 21, 1809. Died in 1852.
Lawford, Frederick, Montreal, Canada (11). Died in 1866.
Lawrence, Edward, Charlestown, Mass. (18). Born June, 1810. Died Oct. 17, 1885.
Le Conte, John L., Philadelphia, Pa. (1). Died Nov. 15, 1883.
Lederer, Baron von, Washington, D. C. (1).
Lieber, Oscar M., Columbia, S. C. (8). Born Sept. 8, 1830. Died June 27, 1862.
Lincklaen, Ledyard, Cazenovia, N. Y. (1). Died April 25, 1864.
Linsley, James H., Stafford, Conn. (1). Born May 5, 1787. Died Dec. 26, 1843.
Lockwood, Moses B., Providence, R. I. (9). Died in 1872.
Logan, William E., Montreal, Canada (1). Born April 23, 1798. Died June 22, 1875.
Loosey, Charles F., New York, N. Y. (12).
Lothrop, Joshua R., Buffalo, N. Y. (15).
Lowrie, J. R., Warriorsmark, Pa. (29). Died Dec. 10, 1885.
Lyon, Sidney S., Jeffersonville, Ind. (20). Born Aug. 4, 1808. Died June 24, 1872.

M'Conihe, Isaac, Troy, N. Y. (5).
McFadden, Thomas, Westerville, Ohio (30). Born Nov. 9, 1825. Died Nov. 9, 1883.
McMahon, Mathew, Albany, N. Y. (11).
Maack, G. A., Cambridge, Mass. (18). Died in Aug., 1873.
Mahan, Dennis H., West Point, N. Y. (9). Born April 2, 1802. Died Sept. 16, 1871.
Marsh, Dexter, Greenfield, Mass. (1).
Marsh, James E., Roxbury, Mass. (10).
Martin, B. N., New York, N. Y. (23). Died Dec. 26, 1883.
Mather, William W., Columbus, Ohio (1). Born May 24, 1804. Died Feb. 27, 1859.
Maude, John B., St. Louis, Mo. (27). Died in April, 1879.

Maupin, S., Charlottesville, Va. (10).
Meade, George G., Philadelphia, Pa. (15). Born Dec. 30, 1815. Died Nov. 6, 1872.
Meek, F. B., Washington, D. C. (6). Born December 10, 1817. Died December 21, 1876.
Meigs, James Aitken, Philadelphia, Pa. (12). Born July 30, 1829. Died Nov. 9, 1879.
Minifie, William, Baltimore, Md. (12). Born in 1805. Died Oct. 24, 1880.
Mitchel, O. M., Cincinnati, Ohio (3). Born Aug. 28, 1810. Died Oct. 30, 1862.
Mitchell, William, Poughkeepsie, N. Y. (2). Died April 2, 1869, aged 76.
Mitchell, Wm. H., Florence, Ala. (17).
Morgan, Lewis H., Rochester, N. Y. (10). Born Nov. 21, 1818. Died Dec. 17, 1881.
Morgan, Mrs. Mary E., Rochester, N. Y. (31). Died in 1884.
Morris, John B., Nashville, Tenn. (26).
Morton, Samuel G., Philadelphia, Pa. (1). Born Jan. 26, 1799. Died May 15, 1851.
Mudge, Benjamin F., Manhattan, Kansas (25). Born Aug. 11, 1817. Died Nov. 21, 1879, aged 62.
Monroe, Nathan, Bradford, Mass. (6). Born May 16, 1804. Died July 8, 1866.
Monroe, William, Concord, Mass. (18). Died April 27, 1877.
Muir, William, Montreal, Can. (31). Died July, 1885.
Mussey, William H., Cincinnati, Ohio (30). Born Sept. 13, 1818. Died Aug. 1, 1882.

Newland, John, Saratoga Springs, N. Y. (28). Died Jan. 18, 1880.
Newton, E. H., Cambridge, N. Y. (1).
Nichols, Charles A., Providence, R. I. (17). Born Jan. 4, 1826. Died Oct. 20, 1877.
Nicholson, Thomas, New Orleans, La. (21).
Nicollett, Jean N., Washington, D. C. (1). Born July 24, 1786. Died Sept. 11, 1843.
Norton, John P., New Haven, Conn. (1). Born in July, 1822. Died Sept. 5, 1852.
Norton, W. A., New Haven, Conn. (6).
Noyes, J. O., New Orleans, La. (21).
Nutt, Cyrus, Bloomington, Ind. (20). Died in 1875.

Oakes, Wm., Ipswich, Mass. (1). Born July 1, 1799. Died July 31, 1848.
Ogden, Robert W., New Orleans, La. (21). Died March 24, 1878.
Ogden, William B., High Bridge, Westchester Co., N. Y. (17). Born in 1805. Died Aug. 3, 1877.
Olmsted, Alexander F., New Haven, Conn. (4). Born Dec. 20, 1822. Died May 5, 1853.

Olmsted, Denison, New Haven, Conn. (1). Born June 18, 1791. Died May 13, 1859.

Olmsted, Denison, jr., New Haven, Conn. (1). Born Feb. 16, 1824. Died Aug. 15, 1846.

Orton, James, Poughkeepsie, N. Y. (18). Died Sept. 24, 1877.

Osbun, Isaac J., Salem, Mass. (29).

Otis, George Alexander, Washington, D. C. (10). Born Nov. 12, 1830. Died Feb. 23, 1881.

Packer, Harry E., Mauch Chunk, Pa. (30). Died Feb. 1, 1884.

Painter, Jacob, Lima, Pa. (23). Died in 1876.

Painter, Minshall, Lima, Pa. (7).

Parker, Wilbur F., West Meriden, Conn. (23). Died in 1876.

Parkman, Samuel, Boston, Mass. (1). Died Dec. 15, 1854, aged 38.

Parsons, Henry B., New York, N. Y. (30). Born in 1855. Died Aug. 21, 1885.

Payn, Charles H., Saratoga Springs, N. Y. (28). Born May 16, 1814. Died Dec. 20, 1881.

Peirce, B. O., Beverly, Mass. (18). Died Nov. 12, 1883, aged 71 years.

Peirce, Benjamin, Cambridge, Mass. (1). Born April 4, 1809. Died Oct. 6, 1880.

Perkins, George R., Utica, N. Y. (1). Born May 3, 1812. Died Aug. 22, 1876.

Perkins, Henry C., Newburyport, Mass. (18). Born Nov. 13, 1804. Died Feb. 2, 1873.

Perry, John B., Cambridge, Mass. (16). Died Oct. 3, 1872, aged 52.

Perry, M. C., New York, N. Y. (10).

Phelps, Mrs. Almira Hart Lincoln, Baltimore, Md. (13). Died July 15, 1884, in her 91st year.

Phillips, John C., Boston, Mass. (29). Died March 1, 1885, aged 46 yrs. 9 mos.

Piggot, A. Snowden, Baltimore, Md. (10).

Platt, W. G., Philadelphia, Pa. (32). Died Nov. 1885.

Plumb, Ovid, Salisbury, Conn. (9).

Pope, Charles A., St. Louis, Mo. (12). Born May 15, 1818. Died July 6, 1870.

Porter, John A., New Haven, Conn. (14). Born March 15, 1822. Died Aug. 25, 1866.

Potter, Stephen H., Hamilton, Ohio (30). Born Nov. 10, 1812. Died Dec. 9, 1883.

Pourtalès, Louis François de, Cambridge, Mass. (1). Born in 1822. Died July 18, 1880.

Pruyn, John V. L., Albany, N. Y. (1). Born June 22, 1811. Died Nov. 21, 1877.

Pugh, Evan, Centre Co., Pa. (14).

Pulsifer, Sidney, Philadelphia, Pa. (21). Died March 24, 1884.

Putnam, Mrs. F. W., Cambridge, Mass. (19). Born Dec. 29, 1838. Died March 10, 1879.
Putnam, J. Duncan, Davenport, Iowa (27). Born Oct. 18, 1855. Died Dec. 10, 1881.

Read, Ezra, Terre Haute, Ind. (20). Died in 1877.
Redfield, William C., New York (1). Born March 26, 1789. Died Feb. 12, 1857.
Resor, Jacob, Cincinnati, Ohio (8). Died in 1871.
Robb, James, Fredericton, N. B. (4).
Robinson, Coleman T., Buffalo, N. Y. (15).
Rockwell, John A., Norwich, Conn. (10). Born August 27, 1803. Died February 10, 1861.
Rogers, Henry D., Glasgow, Scotland (1). Born 1809. Died May 29, 1866.
Rogers, James B., Philadelphia, Pa. (1). Born February 22, 1803. Died June 15, 1852.
Rogers, Robert E., Philadelphia, Pa. (18). Died Sept. 7, 1884.
Rogers, William Barton, Boston, Mass. (1). Born Dec. 7, 1804. Died May 30, 1882.
Root, Elihu, Amherst, Mass. (25). Born Sept. 14, 1845.

Sager, Abram, Ann Arbor, Mich. (6). Born December 22, 1810. Died August 6, 1877.
Sanders, Benjamin D., Wellsburg, W. Va. (19).
Schaeffer, Geo. C., Washington, D. C. (1). Died in 1873.
Schley, William, New York, N. Y. (28). Died in 1882.
Scott, Joseph, Dunham, C. E. (11). Died in 1865.
Seaman, Ezra C., Ann Arbor, Mich. (20). Born Oct. 14, 1805. Died in his 74th year.
Senter, Harvey S., Aledo, Ill. (20). Died in 1875.
Seward, William H., Auburn, N. Y. (1). Born May 16, 1801. Died Oct. 10, 1872.
Sheppard, William, Drummondville, Province of Quebec, Can. (11). Born in 1783. Died in 1867.
Sherwin, Thomas, Dedham, Mass. (11). Born March 26, 1799. Died July 23, 1869.
Silliman, Benjamin, New Haven, Conn. (1). Born August 8, 1779. Died November 22, 1864.
Silliman, Benjamin, New Haven, Conn. (1). Born Dec. 4, 1816. Died Jan. 14, 1885.
Skinner, John B., Buffalo, N. Y. (15). Died in 1871.
Slack, J. H., Philadelphia, Pa. (12).
Smith, Charles A., St. Louis, Mo. (27). Died in 1884.
Smith, David P., Springfield, Mass. (29). Born Oct. 1, 1830. Died Dec. 26, 1880.
Smith, Mrs. Erminnie A., Jersey City, N. J. (25). Died June 9, 1886.

Smith, J. Lawrence, Louisville, Ky. (1). Born Dec. 16, 1818. Died Oct. 12, 1883.

Smith, J. V., Cincinnati, Ohio (5).

Smith, James Y., Providence, R. I. (9). Born September 15, 1809. Died in 1876.

Smith, Lyndon A., Newark, N. J. (9). Born November 11, 1795. Died December 15, 1865.

Snell, Ebenezer S., Amherst, Mass. (2). Born October 7, 1801. Died in September, 1877.

Sparks, Jared, Cambridge, Mass. (2). Born May 10, 1789. Died March 14, 1866.

Spinzig, Charles, St. Louis, Mo. (27). Died Jan. 22, 1882.

Stearns, Josiah A., Boston, Mass. (29).

Stimpson, William, Chicago, Ill. (12). Died May 26, 1872.

Stone, Samuel, Chicago, Ill. (17). Born Dec. 6, 1798. Died May 4, 1876.

St. John, Joseph S., Albany, N. Y. (28). Died Nov. 23, 1882.

Sullivant, William S., Columbus, Ohio (7). Born Jan. 15, 1803. Died April 30, 1873.

Sutton, George, M.D., Aurora, Ind. (20). Died June 13, 1886.

Swain, James, Fort Dodge, Iowa (21). Born in 1816. Died in 1877.

Tallmadge, James, New York, N. Y. (1). Born Jan. 20, 1778. Died Oct. 3, 1853.

Taylor, Arthur F., Cleveland, Ohio (29). Born Dec. 10, 1853. Died June 28, 1883.

Taylor, Richard C., Philadelphia, Pa. (1). Born January 18, 1789. Died November 26, 1851.

Tenney, Sanborn, Williamstown, Mass. (17). Born in January, 1827. Died July 11, 1877.

Teschemacher, J. E., Boston, Mass. (1). Died Nov. 9, 1853, aged 63.

Thompson, A. Remsen, New York, N. Y. (1). Died in Oct., 1879.

Thompson, Alexander, Aurora, N. Y. (1).

Thompson, Zadock, Burlington, Vt. (1). Born May 23, 1796. Died Jan. 19, 1856.

Thomson, Henry R., Crawfordsville, Ind. (30). Died in 1884.

Thurber, Isaac, Providence, R. I. (9).

Tillman, Samuel D., Jersey City, N. J. (15). Died in 1875.

Tobin, Thomas W., Louisville, Ky. (30). Died Aug. 4, 1883.

Todd, Albert, St. Louis, Mo. (27). Died April, 1885, aged 72 years.

Tolderoy, James B., Fredericton, N. B. (11).

Torrey, John, New York, N. Y. (1). Born Aug. 15, 1796. Died March 10, 1873.

Torrey, Joseph, Burlington, Vt. (2). Born Feb. 2, 1797. Died Nov. 26, 1867.

Totten, Joseph G., Washington, D. C. (1). Born August 23, 1788. Died April 22, 1864.

Townsend, Howard, Albany, N. Y. (10). Died in 1867.

Townsend, John K., Philadelphia, Pa. (1).
Townsend, Robert, Albany, N. Y. (9). Died in 1866.
Troost, Gerard, Nashville, Tenn. (1). Born March 15, 1776. Died Aug. 14, 1850.
Tuomey, Michael, Tuscaloosa, Ala. (1). Born September 29, 1805. Died March 20, 1857.
Tyler, Edward R., New Haven, Conn. (1). Died Sept. 28, 1848.

Vancleve, John W., Dayton, Ohio (1).
Vanuxem, Lardner, Bristol, Pa. (1).
Vaux, William S., Philadelphia, Pa. (1). Born May 19, 1811. Died May 5, 1882.

Wadsworth, James S., Genesee, N. Y. (2). Born October 30, 1807. Died May 8, 1864.
Wagner, Tobias, Philadelphia, Pa. (9).
Walker, Joseph, Oxford, N. Y. (10).
Walker, Sears C., Washington, D. C. (1). Born March 28, 1805. Died January 30, 1853.
Walker, Timothy, Cincinnati, Ohio (4). Born Dec. 1, 1802. Died Jan. 15, 1856.
Walsh, Benjamin D., Rock Island, Ill. (17).
Wanzer, Ira, Brookfield, Conn. (18). Born April 17, 1796. Died March 5, 1879.
Warren, Geo. Washington, Boston, Mass. (18). Died in 1884.
Warren, Gouverneur Kemble, Newport, R. I. (12). Died Aug. 8, 1882, in his 64th year.
Warren, John C., Boston, Mass. (1). Born Aug. 1, 1778. Died May 4, 1856.
Watertown, Charles, Wakefield, Eng. (1).
Watkins, Samuel, Nashville, Tenn. (26).
Watson, J. Craig, Ann Arbor, Mich. (13). Born Jan. 28, 1838. Died Nov. 23, 1880.
Webster, Horace B, Albany, N. Y. (1). Died Dec. 8, 1843.
Webster, J. W., Cambridge, Mass. (1). Died Aug. 30, 1850, aged 57.
Webster, M. H., Albany, N. Y. (1).
Weed, Monroe, Wyoming, N. Y. (6). Died in 1867.
Welch, Mrs. G. O., Lynn, Mass. (21). Died in June, 1882.
Weyman, George W., Pittsburg, Pa. (6). Born April, 1832. Died July 16, 1864.
Wheatland, Richard H., Salem, Mass. (13). Born July 6, 1830. Died Dec. 21, 1863.
Wheatley, Charles M., Phœnixville, Pa. (1). Died May 6, 1882.
Wheeler, Arthur W., Baltimore, Md. (29). Born in March, 1859. Died Jan. 6, 1881.
White, Samuel S., Philadelphia, Pa. (23). Died Dec. 30, 1879.
Whiting, Lewis E., Saratoga Springs, N. Y. (28). Born March 7, 1815. Died Aug. 2, 1882.

Whitman, Edmund B., Cambridge, Mass. (29). Died Sept. 2, 1883.
Whitman, Wm. E., Philadelphia, Pa. (23). Died in 1875.
Whitney, Asa, Philadelphia, Pa. (1). Born Dec. 1, 1791. Died June 4, 1874.
Whittlesey, Charles C., St. Louis, Mo. (11). Died in 1872.
Wilder, Graham, Louisville, Ky. (30). Born July 1, 1843. Died Jan. 16, 1885.
Willard, Emma, Troy, N. Y. (15). Born Feb. 23, 1787. Died April 15, 1870.
Williams, Frank, Buffalo, N. Y. (25). Died Aug. 13, 1884.
Williamson, R. S., San Francisco, Cal. (12).
Wilson, W. C., Carlisle, Pa. (12).
Winlock, Joseph, Cambridge, Mass. (5). Born Feb. 6, 1826. Died June 11, 1875.
Woodbury, Levi, Portsmouth, N. H. (1). Born Dec. 22, 1789. Died Sept. 4, 1851.
Woodman, John S., Hanover, N. H. (11). Born in 1813. Died May 15, 1871.
Woodward, J. J., Washington, D. C. (28). Born Oct. 30, 1833. Died Aug. 17, 1884.
Wright, Elizur, Boston, Mass. (31). Born Feb. 12, 1804. Died Nov. 20, 1885.
Wright, John, Troy, N. Y. (1).
Wyman, Jeffries, Cambridge, Mass. (1). Born Aug. 11, 1814. Died Sept. 4, 1874.

Yarnall, M., Washington, D. C. (26). Born in 1817. Died Jan. 27, 1879.
Young, Ira, Hanover, N. H. (1). Died Sept. 14, 1858, aged 57.

ADDRESS

BY

PROFESSOR J. P. LESLEY,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

My Friends: I have the honor to address you this evening as an association of representatives of American science in all its branches,—as students of the sky and all its elemental forces, of the earth and all its mineral constituents, of the animal and vegetable kingdoms in their past and present ages, of the history and constitution of the human race,—and I may be easily pardoned for some trepidation in view of the draughts you may have drawn in advance on my slender exchequer. I have lain awake o'nights, like my predecessors, reflecting how I should meet my liabilities; and like them, no doubt, I find myself poorer than when, a year ago, I contracted them. You would scorn to receive in payment my promissory notes or mortgages on my castles in Spain. You will accept nothing but gold and silver, in bullion or in coin; and that is what troubles me.

There were once halcyon days for orators: the world of knowledge limited, and canopied with rosy clouds of curious speculation; the birds of fancy singing in every bush; the dew of novelty glittering on the fields. Science was then an early morning stroll with sympathetic friends, uncritical and inexpert, to whom suggestions were as good as gospel truths. Then such a reunion as this to-night was a sort of picnic-party at some picturesque place on the shore of the unknown, hilarious and convivial.

All that has passed away. The sun of science now rides high in heaven, and floods the earth with hot and dusty light. What was once play has turned to serious toil. Shadows are short. Objects present themselves in well-defined and separated shapes

for critical examination. The few and early risers have become a multitude. The tumult of occupations distracts the studious observer. No one lends ear to chit-chat. All are hurried. Critics abound. "Say what you want, and go; or tell us something absolutely true and useful" is the introduction to every conversation. Morning, noon, and night, men demand, not the agreeable, but the necessary. The age of romance in science is part of the forgotten past. The new world has grown gray-haired in fifty years, intolerant of the irresponsibility, the sportiveness, the poetry, the music, the superstitions, the affections, of its youth; dealing only in hard facts,and in their causes and consequences; weighing and measuring all things; analyzing all things; collating, comparing, and classifying; insisting upon investigation at all points; formulating rigid laws; scoffing at the unseen and unknowable; and transmuting the fear of God and the hopes of heaven into a zeal for the exact determination of the units of force, and a confident expectation that railroads will soon traverse the unoccupied regions of the earth, and malleable steel replace wood in the mechanic arts.

You represent this new world, grown so suddenly old, learned, utilitarian and critical. Your orators have a hard time of it.

Am I to be the mouthpiece of the outside world, setting forth in order what it has expected of you; its praise; its blame? Nay, what care you for praise from uninspired lips? Or what care you for blame from the vulgar herd who comprehend neither your purposes nor your methods?

Am I to be your mouthpiece to inform this outside world of what the community of science which you partly represent has been about the last twelve months, giving it such a catalogue of facts discovered, and theories established or improved, that it shall stand amazed, and bless its stars, and worship? Then this address would simply be a grandiloquent stage-aside in the drama of this meeting, and no address to you.

Must I then speak to you as a fellow-worker in science, contributing some fresh gift to our common stock of truths? But that would be better done, if done at all, by reading a paper on the subject in the section to which I properly belong.

I did, indeed, hesitate a while before I rejected a temptation to discuss before you this evening one or two subjects on which I have reflected for many years,— for instance: the important *role* which the chemical solution of the limestone formations has played in

the grand drama of the topography of the globe; the absolute inconstancy of the ocean-level; the function of variable deposition in closed basins in elevating the plane at which coal-vegetation repeated itself; the influence which anticlinals and synclinals *en échelon* have exercised in originally directing, and afterwards perpetually shifting, the systems of river-drainage, as the general surface became lower and lower through erosion; the extraordinary differences in the amount and rate of erosion in different parts of the same region, due to the various heights and shapes of the plications,— but a deep sense of insufficiency for properly handling such great subjects deterred me from the attempt. They demand the largest treatment, the fullest illustration, and the long coöperation of many minds. All the great transcendental questions of science remain open to research; not one of them has as yet been answered satisfactorily; all answers have been premature, and most of what has been published for such seems to me puerile; yet the disposition to deal in transcendental science seems to grow daily stronger. There are no laws, however, against initiation into Alpine clubs. If men choose to run fatal risks for notoriety, let them do so, in the name of all that is chilly and unprofitable; but let them not pretend that, when they reach the summit of some Jungfrau or Matterhorn, their demon of adventure shows them all the kingdoms of the world of science, and the glory of it; for in fact the inaccessible sky surrounds them still, and clouds obstruct their vision in every direction. I have no fancy for such mountain-climbing, and think lightly of exploits so barren of results.

I seize the occasion rather to awake to your remembrance some thoughts of common interest, which the multiplying avalanches of facts and theories threaten to bury out of sight, as the pure ice of the glacier gets covered over with a sordid sheet of *débris* perpetually tumbling from the cliffs between which it flows.

Consider then, first, that the final cause of a glacier is not to carry moraines, lateral or medial; that these are mere accidents of its existence; and that, were it endowed with intelligence, it would feel little interest and less pride in the heterogeneous, variable, and for the most part useless burden, which it cannot escape, and throws away at the close of its career. Such are the loads of science which we are compelled to carry forward, through life, in the forms of fact and theory; misshapen accidental droppings upon us from our local surroundings; fragmentary specimens of know-

edge, of which we construct our confused and shapeless heaps of learning, most of which is of little use either to ourselves or to the world. The life of the glacier is an elaboration of the universal moisture into snow, névé, and pure ice, by a slow process of internal constitution; and such is the happy destiny of the true man of science, worked out in wisdom of character, apart from all accidental accumulations of learning, and mainly irrespective of them.

Let us avoid the sacrifice of character to science. As the saying of Jesus of Nazareth that the sabbath was made for man, not man for the sabbath, has rung through the centuries a tocsin of alarm to rouse mankind to resist ecclesiasticism, so let the warning cry fill the air of our association, from meeting to meeting, that science is our means, and not our end. Self-culture is the only real and noble aim of life. And as the magnificence, beauty, and utility of a glacier, as a perpetual reservoir of solid moisture, is not gauged by the size, arrangement, or constitutional features of its moraines, neither is the greatness and usefulness of the philosopher measured by his amount of the knowledge of the physical fact-and-theory science of the times.

Of all kinds of intellectual greatness the greatest is achieved by the philosopher who stands before the thinking world as a model of scientific virtue; deaf to flattery; insensible to paltry hostile criticism; patient of opposition; dead to the temptations of self-interest; calmly superior to the misjudgments of the short-sighted; whom nothing diverts from the endeavor to live nobly, and to whom noble means are as indispensable as noble ends; in whom the most brilliant successes foster neither vanity nor arrogance; to whom fame is unimportant, and poverty a trivial circumstance; whose joys, like fragrant breezes from an encircling landscape, come from the surrounding friendship of the general world, to whose best interests the noble heart is forever loyal.

Another subject for serious reflection is the over-accumulation of scientific information. To broach it before such an assembly may seem to require some apology. Certainly the feeling prevails that the world cannot have too much science. But the science of learning and the science of knowledge are not quite identical; and learning has too often, in the case of individuals, overwhelmed and smothered to death knowledge. The average human mind, when overstocked with information, acts like a general put in command

of an army too large for him to handle. Many a vaulting scientific ambition has been thus disgraced. Nor is this the only danger that we run; for the accumulation of facts in the treasury of the human brain has a natural tendency to breed an intellectual avarice, a passion for the piling-up of masses of facts, old and new, regardless of their uses. In the great game of our spiritual existence, facts are mere counters with which to play the game. A million of them are worth nothing, unless the player knows how to play well the game; and when the game is over the worthless counters are swept back into the drawer. And the danger pursues us to higher and higher planes of science. Not only the avarice of facts, but of their explanations also, may end in a wealthy poverty of intellect for which there is no cure. Even the sacred fires of research may be allowed to burn too long, until, in fact, they turn the investigator into a mere miser of ideas. As for those who are not themselves original investigators, but busy themselves incessantly in appropriating the secretions of research at second hand, how often it happens that the richest additions of reliable theories to the stock of their ideas, even to a point where they suppose themselves, and are supposed by others, to know all the conclusions arrived at by past and present inquirers, leave them as thinkers just what they were at first — incompetents; mere ill-hung picture-galleries; disarranged museums; complicated inventions which will not work; costly expeditions for discovery, frozen fast and abandoned in the polar ice.

A certain temperance in science is obligatory from another point of view. As mere wealth of possessions cannot guarantee happiness, neither can a superfluity of learning insure wisdom. When the body from overfeeding grows plethoric its vital energies subside and its life is endangered. The intellect may be mischievously crammed with science. How much we know is not the best question, but how we got what we know; and what we can do with it; and above all what it has made of us. The tendency of training now is to subordinate the soul to that which should be only its endowment and adornment; to turn the thinker into a mere walking encyclopedia, text-book, or circle of the mechanic arts; not to produce the highest type of man. What ridiculous and pitiable creations are these!—an authority in physics who cannot speak the truth? a leader in natural history who is given over to the torments of envy? a god in chemical research sick of some false

quotation? a youthful prodigy of mathematical science tottering with unelastic steps and outstretched arms to grasp his future fame? Yet no one will deny that the intemperate pursuit of any branch of science has a tendency to produce such characters, by elevating to undue importance the individual accumulation of scientific facts and scientific theories, to the neglect and depreciation of that spirit of truth which alone can inspire and justify an earnest study of the material universe. I beg you to reflect that it is as true of science as of religion, that the mere letter of its code threatens its devotee with intellectual death; and that only by breathing its purest spirit can the man of science keep his better character alive,— that indefinable spirit which, in its intimate and essential nature, has little to do with the number of facts discovered, or theories accepted; a spirit which merely exercises itself in research, and accepts discoveries as delightful accidents; a spirit which walks the paths of science, not as if they were turnpikes converging upon some smoky and squalid focus of toil-wearied population, but as if they had been gravelled and flower-bordered for it through some princely park; a spirit of natural and cultivated nobleness, sweetened by boundless friendship for the world and all that lives therein; just and true to all men worthy or unworthy, proud without vanity, industrious without haste, stating its own griefs as lightly as an angel might, and generously bringing help to the discouraged and forlorn. In every one of us there is this genius, if we did but know it; and, as Emerson well says, the moral is the measure of its health.

I have been saying, then, that we should pursue science, like any other business of this life, with a distinct and unwavering intention to ennoble our own characters. It were a trite addition to propose that the pursuit be made ancillary to the public good. "The love of science" is a phrase which has been greatly glorified in popular discourse; and if the phrase be confined to its true meaning — a zealous admiration for all that is beautifully true and useful in nature— it cannot harm us in the practice of our profession.

But when the imagination has exhausted itself in transcendental ecstasies over an ethereal sentiment so named, but undescribed except in poetry, what wiser or better thing is left to say of any branch of physical or natural science cultivated by our association than that its votaries are knowingly or unknowingly bettering

the condition and character of mankind? Every advancement in science is of its own nature an improvement of the commonwealth. Every successful study of the laws of the world we inhabit inevitably brings about a more intelligent and victorious conflict with the material evils of life, encouraging thoughtfulness, discouraging superstition, exposing the folly of vice, and putting the multitudes of human society on a fairer and friendlier footing with one another. The arts of philanthropy are therefore as direct an outcome of science as is the lighting of the public streets, or the warming of our homes. Cruelty and shame are products of the night. The daylight is a friend to friendliness. The progress of civilization and the progress of science are alike typified by the progressively brilliant and general illumination of cities. So, in old times, human sacrifices and piracy ceased wherever the worship of the Tyrian Melcarth yielded place to the philosophy, belles-lettres, and fine arts of the genial and beautiful Delphic Apollo, the civilizer, the far shiner, the sun of Grecian righteousness, whose initiated became the educators of the modern world.

And yet these two magic words, "initiation," "education," have meanings directly the reverse of one another,— the one a *going in* to learn the secrets of esoteric doctrine, unsafe for publication because immature; the other a *being led out* from ignorance to knowledge, from helplessness to the active performances of life. The idea of universal education is wholly modern; in fact, a product of the century in which we live. It is democracy in the world of intellect. It is the doctrine of equal human rights applied to the possessions of the human brain. It is the apotheosis of common sense. It demands the distribution of knowledge in adequate quantity and quality to all who live and all who are to live upon the earth. How this is to be accomplished is the greatest of the questions of the day; and it especially concerns us as members of an association for the advancement of science.

I do not intend to discuss the subject, to define the quantity and quality of knowledge adequate for the various classes of human society, or to propose any plans for its distribution. All I wish to say about it is, that it seems to me that nature limits the responsibilities of teachers and the rights of learners more narrowly than is commonly supposed. The parable of the sower is a good reference for explanation. Most of the surface of the globe is good for little else than cattle-ranches or sheep-farms; and the large

majority of mankind must, in all ages, be satisfied with the mere rudiments of learning: what they want is unscholastic wisdom with which to fight the fight of life, and they must win it for themselves. Only a limited number of persons in any community can acquire wealth of knowledge; and the only thought on which I wish to insist is this: these few must also get it for themselves, and moreover must work hard for it.

It is a hackneyed aphorism, that there is no royal road to knowledge, although an incredible amount of pains has been taken to make one. Nature, in this affair, as usual, has been a good wise mother to us all; for it is not desirable to make the acquisition of knowledge easy; for the main point in scientific education is to secure the highest activity of the human mind in the pursuit of truth; an activity tried and disciplined by hardship, and nourished on hardy fare. The quantity of food is of less importance; everything depends on establishing a good constitutional digestion. The harder the dinner is to chew, the stronger grows the eater. Canned science, as a steady diet, is as unwholesome for the growing mind as canned fruits and vegetables for the growing body. The wise teacher imitates the method of nature, who has but one answer for all questions: "Find it out for yourself, and you will then know it better than if I were to tell you beforehand."

But who can be a wise teacher who has not been wisely taught? The spirit of this scientific age favors a universal manufacture of condensed milk to ease and cheapen the toil of bringing up its infants. It finds the bottle of literature more convenient than the breast of nature. It prefers a large family of puny children to a few young heroes. The stalwart ancients exposed their unfit offspring to the wolves; we moderns exhaust the resources of art to preserve their worthless and painful lives.

This is the spirit which invents a thousand futile plans for compacting the universe to a size so small, and a shape so simple, that it can be grasped without much effort by the tiniest and feeblest hands. Will it be an unpardonable crime for me to say that I recognize the same spirit in the present popular rage for an over-classification, unification, and simplification of science; for ultra-symmetrical formulæ, and excessive uniformity in nomenclature; with an avowed reference to ease of learning and convenience of teaching, the saving of time in the acquisition of facts, and the diminution of brain-waste in collating them for use; in

one word, to the making of science easy, in despite of the inexorable decree of nature that it always shall be and always ought to be difficult? For the genius of the creation is visibly hostile to that uniformity, symmetry, and orderly simplicity which the text-book endeavors to establish. No logical consistency for her! No stiffening of the fact-producing energies into fact-formularies will she endure. Hardly has a manual issued from the press but it is mutilated by her puckish fingers. No sooner has some school of theorists erected a stately structure in simple grandeur than it is shattered by the lightning of a new revelation. There is no rest, no peace, in our believing. Our libraries contain little else than such spoiled palimpsests; the broad fields of science are covered with such ruins; and those who have grown old in travelling far and wide across them would find little cause for singing pæans to the exploits of science were it not for the fact that the function of science is not to organize nature, but by the laborious study of nature to organize the human mind, and inform it with the very genius of nature, original, unsymmetrical, indefiable, unclassifiable, changing its attitudes and operations every instant, and escaping easily from all the toils of scholastic unification which we spread for it. The work of the student cannot be simplified, cannot be made easy, if it is not to fail in its great purpose the production of a genuine man of science. The foolish nurse thinks it her duty to carry the child always in her arms: but the test of a good education is the ability of the child to carry its nurse: and this it can only attain to through the discipline of toil; toil which at first conceals itself under the gracious guise of sports, gymnastics and adventures, and afterwards takes the shape of experimental failures and useless constructions, but all as free, untutored, and original as the laughing, wasteful, and ungovernable pranks of nature. But I have followed long enough, perhaps you will think too long, this train of thought: let me suggest another.

It is a familiar fact that great discoveries come at long intervals, brought by specially commissioned and highly endowed messengers; while a perpetual procession of humbler servants of nature arrive with gifts of lesser moment, but equally genuine, curious and interesting novelties. The excitement of the pageant incapacitates us for reasoning rightly on its meaning. From what unknown land does all this wealth of information come; who are these bearers of it; and who intrusted each with his particu-

lar burden, which he carries aloft as if it deserved exclusive admiration? Why do those who bring the best things walk so seriously and modestly along, as if they were in the performance of a sacred duty for which they scarcely esteem themselves worthy; while those who have little to show, or things of inferior or doubtful value, strut and grimace magnificently, as if they felt themselves the especial favorites of nature, push to the front, speak loudly to the multitude, and evidently deem themselves entitled to uncommon honors?

In this procession of science, in this interminable show of discovery, two facts arrest attention: first, the eager gaze of expectation which the crowd of lookers-on direct towards the quarter from which the procession comes, and their unaccountable indifference to what has already passed; and secondly, the wonderful disappearance, the more or less sudden vanishing out of the very hands of the carriers, of a large majority of the facts and theories of which they make so pompous an exposure; few of them however seeming to be aware that thereby they have lost their right to participate in the pageant, and should retire from it into the throng of spectators, at least until good fortune should take pity on them and drop some new trifle at their feet to soothe their wounded vanity.

You will not suspect me of depreciating the value of any real discovery, be it merely the finding of a Californian bird on the shore of Massachusetts Bay, or detecting with the naked eye the blazing of a variable star before any telescope had noticed it, or finding some Hadrosaurus bones in a New Jersey marl pit, or a Paradoxides at the Quincy quarries? Such accidents have all the importance of trumpet-notes sounding to boots and saddle. But, after all, the trumpeter is only a trumpeter, although he may imagine himself the colonel of the regiment, or a general in the army. And, indeed, it has happened that to such accidents science has owed some of her best physicists and naturalists. But it was not these their first and therefore most enjoyable discoveries that made them what they afterwards became; nor had they at the outset even the right to an opinion on the value of their finds. Years of strenuous and unrenowned exertion had to follow, in which they published little or nothing new, but gathered up the old, and rediscovered by experiment and observation what the records of the past preserved.

What I deprecate is the claim to special attention made by inexperienced stumblers on forgotten or unnoticed facts, remarkable or otherwise, on the sole ground of the discovery. I deprecate the folly of the youth who, because he has found a spear, leaps into the empty chariot of Achilles and, calling on the Grecian host to follow him, lashes the horses for an immediate attack on Troy; nor finds it out until he is half way across the plain that he rides alone and to destruction. I feel no admiration, no respect, for the audacity with which our young recruits of science rush unpanoplied into the thick of a discussion involving the greatest thinking of the age. They act like animals at a conflagration. I hear on all sides a noisy tumult of untrained intellects. Shall such themes as the nebular hypothesis, the probable solidity or fluidity of our planet, the metamorphosis of rocks, the origin of serpentine or petroleum, the cause of foliation, the stable or unstable geographical relationships of continent to ocean, the probable rate of geological time, the conditions of climate in the ages of maximum ice, the probable centres of life-dispersion, the unity or multiplicity of the human race, the evolution of species, be babbled over by men the amount of whose efficient work in any branch of science is measurable with a foot-rule; while those whose entire lives have been but one exhausting struggle with the shapes which people the darkness of science speak with bated breath and downcast eyes of these great mysteries?

There is a shibboleth by which tyros in science can always be detected,—their habitual employment of the words "doubtless," "certainly," and "demonstrated." To their inexperience of the universality of error every new statement in print over a name noted in science reads like a revelation of the absolute; and every conclusion at which they themselves arrive, after a more or less superficial study of the limited number of facts which accident has given them the opportunity to observe, seems a conclusion too real to be impugned. I love the remembrance of my youth, but I regret its dogmatic impertinences. Young votaries of science draw their inspiration from the maxim which best suits them,—"try the value of old truths by new discoveries." The veterans of science reverse the rule, and test all new discoveries by a world of half-forgotten facts and well-established principles. The advancement of science is accomplished by the push and pull of these two ruling motives. No science were possible if the aged could sup-

press the youthful, or the youthful could extirpate the aged. But as surely as the agnosticism of age is a witness to the weariness of fruitless speculation, so surely the confidence of youth that every movement must of necessity be forward is a proof of insufficiency.

Let the military art instruct us. The raw recruit is satisfied if old Blücher waves his sword shouting Vorwärts! But the sobered veteran is prepared to see in flank movements, in retreats, in halts and intrenchments, steps of the campaign as necessary as any charge at double-quick on hostile lines, or a steady march in column into the enemy's country. Let us suppose that in the last twelve-month not one surprising discovery in any region of the globe has been made; that a hundred previously reported facts have been examined and pronounced untrue; a hundred printed memoirs, widely read and criticised, been proved mistaken or absurd; a hundred long-accepted generic or specific names, fossil or recent, have been expunged from the lists; and that others, like *Halysites catenulata*, or *Spirifer disjuncta*, have lost their characteristic values; suppose any amount of doubt to have been thrown upon any number of popularly accepted theories, by failures in applying them to practice, like the theory of the anticlinal location of gas-wells; in a word, suppose any amount of smashing in any department of the great crockery-shop of transcendental or applied science,— what does it imply but a tendency of all inquiry, observation, investigation, and experiment towards the betterment, which is the only true advancement, of science? As in the animal kingdom the peaceful kinds are offset and held in check by analogous carnivores, for fear of over-population; so in the world of thought the constructive theorists are perpetually preyed upon by a corresponding class of natural enemies, the destructive critics, which keeps the field open and the air sweet. The destruction of effete knowledge is the perennial birth of that science which cannot be destroyed. But in recognizing this fact we should remember that there is a science of items and a science of fundamentals, which bear a relation to each other like that which subsists between the individuals of a species and species *per se;* and that an indefinite multiplication of individuals may go on without any visible modification of their specific character. The population of Europe has grown in the last century from a hundred and fifty to three hundred and twenty millions of souls; but they are the same Teutons, Celts,

and Sclaves as ever. On the other hand, the curve of population for France is almost a horizontal straight line; but their national advancement has been phenomenal. What I wish to illustrate is this evident truth, that not by the mere increment in number of facts learned, not by the mere multiplication of discoverers, teachers and students of those facts, but by the elevation of our aims, by the enlargement of our views, by the refinement of our methods, by the ennoblement of our personalities, and by these alone can we rightly discover whether or not our association is fulfilling its destiny by advancing science in America. If, unhappily, our meetings should rather tend to cultivate a love for *bric-à-brac* in science, if the stimulation and gratification of a quasi-animal curiosity for scientific novelties be fostered, if our discussions should become hot-beds of a more vigorous vegetation of personal vanity, intellectual pugnacity, lust for notoriety, literary jealousies, conceited reclamations, petty ambitions, or pecuniary schemes, how is our day and generation to be benefited or improved? If our attention become restricted to the details of the creation, and to the smaller manœuvres of the forces of nature; or if, on the other hand, we become habituated in the indulgence of vague generalizations, suggestions of possible theories, and half-completed or merely sketched and outlined hypotheses,— how are we ourselves, as workers of science, to escape deterioration?

I cannot shake off a suspicion that we talk and write too much; that the whole world talks too much; and that the golden time for silence is precisely then when we come together to talk. Were each of us to utter only what he absolutely knows, what he is quite sure of, what he has unimpeachable facts in sufficient number to confirm,— what a sudden illumination would overspread our meetings, glorifying our science, and re-inspiring us all! But I turn from the Utopian fancy, and invite your attention to a very different theme.

There is a topic which I think should be frequently considered by all who engage in scientific pursuits; and by none so earnestly as by those who are ambitious to reach the higher points of view from which to survey and describe those systematic combinations of phenomena which are more or less panoramic: I allude of course to generalizers or discoverers of natural laws, and the professional teachers of such laws; while those who deal in itemized science, the mere observers of isolated facts, discriminating specimens and

naming genera and species of the animal, vegetable or mineral worlds, and especially such as occupy themselves with geographical and geological studies in detail, stand in less need of having it pressed upon their attention, because in their case it insists upon its own necessity.

I allude to what is technically known among experts as "dead-work."

This topic has to be treated in the most prosaic style. To describe dead-work is to narrate all those portions of our work which consume the most time, give the most trouble, require the greatest patience and endurance, and seem to produce the most insignificant results. It comprises the collection, collation, comparison and adjustment, the elimination, correction and re-selection, the calculation and representation — in a word, the entire first, second, and third handling of our data in any branch of human learning,— wholly perfunctory, preparatory, and mechanical, wholly tentative, experimental, and defensive,— without which it is dangerous to proceed a single stage into reasoning on the unknown, and futile to imagine that we can advance in science ourselves, or assist in its advancement in the world. It is that tedious, costly, and fatiguing process of laying a good foundation, which no eye is ever to see, for a house to be built thereon for safety and enjoyment, for public uses or for monumental beauty. It is the labor of a week to be paid for on Saturday night. It is the slow recruiting, arming, drilling, victualling, and transporting of an entire army to secure victory in one short battle. It is the burden of dead weight which every great discoverer has had to carry for years and years, unknown to the world at large, before the world was electrified by his appearance as its genius. Let us examine it more closely: it will repay our scrutiny. Those of you who have been more or less successfully at work all your lives may get some satisfaction from the retrospect; and those who have commenced careers should hear what dead-work means, what its uses are, how indispensable it is, how honorable it is, and what stores of health and strength and happiness it reserves for them.

My propositions, then, are these: 1°. That without a large amount of this dead-work there can be no discovery of what is rightly called a scientific truth. 2°. That without a large amount of dead-work on the part of a teacher of science he will fail in his efforts to impart true science to his scholars. 3°. That without

a large amount of dead-work no professional expert can properly serve, much less inform and command, his clients or employers. 4°. That nothing but an habitual performance of dead-work can keep the scientific judgment in a safe and sound condition to meet emergencies, or prevent it from falling more or less rapidly into decrepitude; and 5°, That in the case of highly-organized thinkers, disposed or obliged to exercise habitually the creative powers of the imagination, or to exhaust the will-power in frequently recurring decisions of difficult and doubtful questions, dead-work, and plenty of it, is their only salvation; nay, the most delicious and refreshing recreation; a panacea for disgust, discouragement and care; an elixir vitæ; a fountain of perpetual youth.

In expanding these propositions, I would illustrate them in some such homely ways as should make them seem near and familiar principles of conduct; and of course I can only do this out of the experience of my own life, and from observation of what has happened in the limited sphere of one department of scientific inquiry; but that should suffice, seeing that work is work, and science science, however various may be minds and their pursuits.

First, then, is it so that scientific truths cannot be discovered without a large amount of preliminary dead-work? Surely no one in this assembly doubts it who has established even one original theory for himself, or won for it the suffrages of judges capable of weighing evidence. Now, the immense disproportion in numbers between theories broached and theories accepted is the best proof we could have, not only of the value and necessity of dead-work, but of the scarcity of those who depend upon it as a preparatory stage of theorizing. And, moreover, not theories only, but simple statements of fact believed and disbelieved, that is, finally accepted or finally rejected, exhibit the like numerical disproportion, and betray a general carelessness or laziness of observers; at all events, their manifest lack of appreciation of the value and necessity of the dead-work part of observation which imperatively must precede any clear mental perception of the simplest phenomenon, before the attempt is made to establish its natural relationships, and present it for acceptance as a part of science.

A geologist travels far to collect fossils at a particularly good locality, stops there a day or two, fills his valise, and returns to publish a paper on it. What is his paper worth? Were he first to spend a week in making himself acquainted with the whole vicinity,

a second week in making measured sections of all the cognate outcrops in the neighborhood, a third week in carefully differentiating the specific horizons, and a fourth week in verifying their reliability, and in correcting his first mistakes, then, surely, whatever labor he should afterwards expend upon his collection of life-forms would have its full value; and any paper he might write would be an important contribution to his branch of science.

I have known men settle to their own satisfaction some of the greatest problems in geology by a flying reconnoissance; triumphantly overturning a mass of accumulated science slowly brought to demonstration by many years of conscientious dead-work, which they did not seem to think it worth their while to verify. I have known men reclassify the elements of a geological system by a few sections, not a single one of which was properly measured by them, or could be properly put on paper in a graphic form for precise comparison. I have known men make what they called a geological map, without having run a single instrumental line themselves; with every outcrop inaccurately placed; with only here and there an accidental note of strike and dip, and even this not oriented with a close approximation to precision; covering a region requiring the study of many months, with a few weeks of what they fondly called field-work; and basing on such a map generalizations of the first rank, for which they expected the world of science to give them credit; which in the long run it certainly will, but not the kind of credit they anticipate.

Now, the experience of a long and active life of science has trained me to regard all such work as careless work, lazy work. Not that such workers are lazy men in the common meaning of the word; on the contrary, they are busy, bustling, active, energetic, indefatigable men; in fact, too much so. In science, there is a laziness of quite another definition; namely, a chronic dislike, a deep-seated disability, for the dead-work which first disciplines to accuracy, then makes patient and cautious, and finally bestows the clearest intelligence and largest comprehension of phenomena. And this fatal laziness is fostered by a strange misunderstanding, a fancy, sometimes a downright conviction, that the dead-work of science can be done for us by some one else, so as to save our time and strength for speculation, for thought, for fine writing; can be done by menials, employés, assistants, colleagues, special experts,— by any one rather than by ourselves. Can we not in fact

often find it already done for us, and even better done than we could do it? Then, why not let inferior minds occupy themselves with this laborious and time-consuming address of special skill? Can we not, for instance, hire transit-men to lay out and measure our sections, and artists to draw them? Why should a paleontologist take the pencil between his own fingers in studying species, when he has trained photographers and lithographers at his command? Why waste precious weeks and months in tramping and climbing, in measuring and plotting, while glory calls us, and the scientific world is impatiently waiting for our conclusions? Thus possessed by the demon of scientific haste, we continually spoil our own performances, and disappoint the expectant, but not at all impatient world. Could our vanity permit us to know the fact, the impatience is entirely our own, and, if indulged, is sure to be roundly punished.

No; dead-work cannot be delegated. The man who cannot himself survey and map his field, measure and draw his sections properly, and perfectly represent with his own pencil the characteristic variations of his fossil forms, has no just right to call himself an expert geologist. These are the badges of initiation, and the only guaranties which one can offer to the world of science that one is a competent observer and a trustworthy generalizer. Nor has one become a true man of science until he has already done a vast amount of this dead-work; nor does one continue in his prime, as a man of science after he has ceased to bring to this test of his own ability to see, to judge, and to theorize, the working and thinking of other men. But enough of this.

My second proposition was, that no teacher of science can be successful who does not himself encounter some of the dead-work of the explorer and discoverer; who does not discipline his own faculties of perception, reflection, and generalization by field-work and office-work independently of all text-book assistance; who does not himself make at least some of the diagrams, tables, and pictures for his class-room, in as original a spirit, and with as much precision of detail, as if none such had ever been made before, and these were to remain sole monuments of the genius of investigation. What the true teacher has to do first and foremost is to wake up in youthful minds this spirit of investigation *ab initio*. The crusade against scholastic cramming promises to be successful; but the crusade against pedagogic cramming has hardly yet

been organized. How is the scholar to be made an artist if the teacher cannot draw? The instinct of imitation in man is irresistible. Slovenly drawing on the blackboard — sufficient evidence of the teacher's imperfect information and inaccurate conception of facts, the nature of which he only thinks he understands — can do little more than raise a cold fog of suspicion in the class-room, by which the tender sprouts of learning must be either dwarfed or killed. But even slovenly diagrams are preferable to purchased ones; for whatever diminishes the dead-work of a teacher enervates his investigating, and thereby his demonstrating, powers, and lowers him toward the level of his scholars.

Were I dictator, I should drive all teachers of science out into the great field of dead-work; force them to go through all the gymnastics of original research and its description; and not permit them to return to their libraries until their note-books were full of their own measurements and calculations, sketch-maps and form-drawings, severely accurate and logically classified, to be then compared with those recorded in the books. What teachers fail to keep in mind is this: that learning is not knowledge; but as Lessing says: Learning is only our knowledge of the experience of others; Knowledge is our own. No man really comprehends what he himself has not created. Therefore we know nothing of the universe until we take it to pieces for inspection, and rebuild it for our understanding. Nor can one man do this for another; each must do it for himself; and all that one can do to help another is to show him how he himself has morsellated and recomposed his small particular share of concrete nature, and inspire him with those vague but hopeful suggestions of ideas which we call Learning, but which are not Science.

My third proposition was, that an expert in practical science can command the respect and confidence of his professional fellows, and through their free suffrages build up his own reputation in the learned and business worlds, only in exact proportion to the amount of good dead-work to which he voluntarily subjects himself. For, although the most of it is necessarily done in secrecy and silence, enough of it leaks out to testify to his honest and diligent self-cultivation; and enough of it must show, in the shape of scientific wisdom, to make self-evident the fact that he is neither a tyro nor a charlatan. More than once I have heard the merry jest of the Australasian judge quoted with sinister application to experts in

science. When a young colleague, just arrived from England, asked him for advice, he answered: Pronounce your decisions, but beware of stating your reasons for them. Many an ephemeral reputation for science has been begot by this shrewd policy. But the best policy to wear well is honesty; and honesty in trade means selling what is genuine, well-made, and durable; and honesty in science means, first, facts well proved, and then, conclusions slowly and painfully deduced from facts well proved, in sufficient number and order of arrangement to exhaust alike the subject and the observer. Reap your field so thoroughly that gleaners must despair. Fortify your position so that your most experienced rival can find no point of attack. Lay your plans with such a superfluity of patient carefulness that fate itself can invent no serious emergency. Demonstrate your theory so utterly and evidently that it shall require no defender but itself. Die for your work, that your work may live forever. Forget yourself, and your work will make you famous. Enslave yourself to it, and it will plant your feet upon the necks of kings, and your mere Yes or No will become a law to multitudes. This is what the dead-work of science, when well done, does for the expert in science.

My fourth proposition — that only the habitual performance of dead-work can preserve the scientific intellect in pristine vigor, and prevent it from becoming stiffened with prejudices, inapt to receive fresh truth, and forgetful of knowledge already won — hardly needs discussion. Human muscles become atrophied by disuse. Men's fortunes shrink and evaporate by mere investment. I pray you to imagine what I wish to say; for it all amounts to this — that the grass will surely grow over a deserted footpath. Let me hurry to the close of this address, which I have found too serious a duty for my liking, and perhaps you also have found it too personal a preachment for yours. One more suggestion, then, and I have done.

My fifth proposition was, that the wearied and exhausted intellect will wisely seek refreshment in dead-work.

The physiology of the brain is now sufficiently well understood to permit physicians to prescribe with some assurance for its many ills, and to regulate its restoration to a normal state of health. Its tissues reproduce themselves throughout life if no extraordinary overbalance of decay takes place, if there be no excessive and too long continued waste. For the majority of mankind nature pro-

vides for the adjustment between consumption and reproduction of brain-matter by the alternations of day and night, noise and silence, society and solitude; and also by the substitution of the play of fancy in dreams for the work of the judgment and the will in waking hours. We follow the lead of nature when we seek amusement as a remedy for care. We bring into activity a rested portion of the brain to permit the wearied parts of it to restore themselves unhindered.

This is the rationale of the pathological treatment of the brain. Tell an over-worked president of a railway company, who falls asleep at the directors' meeting, that he must *rest*, or die of softening of the brain, and he will smile a sad reply that he *cannot rest*. He is right, thus far: he cannot rest his whole brain; but he can rest the cerebellum,—the seat of the will power,—by bringing into higher activity and more frequent exercise the upper and frontal lobes. Let him stop thinking of leasing rival lines, and read novels, and play billiards. Let him ride some youthful hobby, revive his practice on the violin, cultivate flowers, keep a stud and kennel, bury himself in Greek and Latin literature, collect pictures, minerals, do any thing which will really interest him and keep him out of the way of railroad men and railroading; and do it with his might, with enthusiasm, even to fatigue; and do it for at least four years, and by that time his cerebellum will be all right again.

Now what the unintermitting responsibilities of the railroad official do for the destruction of the constitution of his cerebellum, just that the overstrained exercise of the creative imagination does for the demoralization of the brain of the man of science, especially if it be, as it commonly is, accompanied by business anxiety. And his only way of escape from a predestined break-down is through the monotonous but interesting occupation of his perceptive faculties in the field and at his office table. In both he will enjoy that solitude which resembles sleep in being a medicine for the weary brain. But it is a solitude peopled with unexceptionable friends; in which care sleeps, and pleasure wakes; a solitude in which the soul multiplies itself by alliance with all the possibilities of number and all the actualities of form; a solitude from which a man returns to the society of his fellow-men sainted by the blessing of nature, and equal to the duty of existence.

In conclusion, I must express the wish that this meeting of our

association may be as delightful and as useful as any that it has ever held. Those who remember how hard we used to work at them, what a harvest of mutual confidences we used to gather at them, and what a glow of fresh enthusiasm we carried away with us from them, will know what such a wish implies. Those who come fresh to this meeting will find themselves made at home in half a dozen worlds of science at once. That is the particular character and special charm of this association, wherein it differs from all local societies, and from all conventions of workers in special branches of science and art. And, as each meeting furnishes a panoramic view of the present state of human knowledge as a whole, so at each meeting the old and the young in science are mingled in such friendly and confidential intercourse that the prospect extends both backwards to the beginnings of inquiry and forwards to its possible achievements. All good tradition is precious; and so is well-trained current inquiry, and so is sound prophetic calculation. At such a meeting as this, we enjoy the rare privilege of assisting at all three; and when we scatter to our homes we can hardly fail to take with us something effectual for lightening and sweetening another year of work.

REPORTS OF COMMITTEES.

THIRD REPORT OF THE COMMITTEE ON STANDARDS OF STELLAR MAGNITUDES. Prof. E. C. PICKERING, reporter.

THE work described in the previous reports of this Committee (*Proc. Amer. Assoc.* XXX, p. 1, XXXIII, p. 29) has been continued during the past year. The scrutiny of the regions from which the standards are selected has been carried on by several members of the committee. The maps of these regions were originally made as stated in the last report with the fifteen inch telescope of the Harvard College Observatory. The most favorable nights were not always employed in this work, and the proximity of the electric lights in Boston doubtless obscured some of the fainter stars. The careful revision with the telescope of the Washburn Observatory, which has also a slightly larger aperture, has doubtless rendered these maps nearly complete, so far as the limit of visibility of telescopes of this size is concerned. A second revision has been made with the Princeton telescope whose aperture is twenty-three inches. Much fainter stars are thus detected. Another revision will probably be undertaken with the Washington telescope of twenty-six inches aperture which should reveal still fainter stars. To secure the faintest stars visible with the largest telescope in the world, hectograph copies have been made of the regions following, γ *Pegasi*, ϵ *Orionis*, η *Virginis*, η *Serpentis*. Copies have been sent to all observatories containing telescopes of the largest size, with the request that all stars visible may be added. If this request is acceded to, we shall have the means also of determining the comparative advantages of telescopes of different forms. Engravings of these charts have been published in the *Astronomical Register*, XXIII, 39, and the *Sidereal Messenger*, IV, 24. Replies have already been received including important additions to the charts from the Melbourne and Strasburg observatories. It is hoped that the results of observations with all the larger telescopes may be received before July, 1886, in order that they may be included in the report for next year.

Meanwhile stars suitable as standards have been selected from each of the twenty-four maps. An attempt was made to choose such as should differ in brightness, on the average, by about half a magnitude, beginning with the brightest stars in the region which are generally not far from the tenth magnitude, and extending to the faintest objects seen. The magnitude of most of these was estimated twice when the charts were made and once when the standards were selected. Measurements were also made with the photometer, designated as I in the *Harv. Observ. Annals*, XI, p. 7, figs. 5 and 6. Each star was observed on three evenings, three settings being made on each evening. The construction of this photometer does not permit the measurement of bright stars. The two brightest stars of each chart, if not too faint, are now being measured with the large meridian photometer at Cambridge. Three sets, each consisting of four settings, are taken of each star. This portion of the work is nearly completed. All stars that were not too faint were also measured on three evenings with the form of wedge photometer described *Proc. Amer. Acad.* XVII, 231. Three settings were made each evening. With this instrument the observations are differential, and it is necessary to determine the constants independently. The constant expressing the opacity of the wedge was found by means of a special photometric investigation. In each series of measures the light of the bright star preceding the group was reduced by a piece of shade glass and then measured by the wedge. Assuming the opacity of the shade glass, a means is thus afforded of reducing all the measures to the scale of the meridian photometer since the preceding bright stars, or leading stars, have all been measured with that instrument. Unfortunately, the shade glass was of a bluish tint and appears to be more opaque to the red stars like *α Tauri*, than to the blue stars. The observations were accordingly reduced by means of the observations of the same stars with the other photometers.

The various determinations of the brightness of the stars selected as standards are compared in Table I. The twenty-four divisions correspond to the various groups of standards and each is preceded by the name, Harvard Photometry number, and magnitude of the leading star. The successive columns give for each star selected as a standard, the letter employed to designate it, the amount it follows the leading star in right ascension, and its declination. The latter is reckoned from the southern edge of the

zone 10′ wide from which the standards are selected. The declinations of the leading stars would therefore be 5′.0. The fourth column gives the magnitudes assumed provisionally for the standards. It is derived from the mean of the measures described above. Magnitudes have been assumed for stars too faint to be measured with any of these photometers. The limiting magnitudes of the stars observed at Cambridge, may be taken at 15.0, although stars have been measured as faint as 15.5. Standards contained on the original charts and not measured will therefore be called 15.0. Those added by the Madison telescope will be somewhat fainter, and will be called 15.1. The aperture of the Princeton telescope should render visible stars nine-tenths of a magnitude fainter, if no other cause entered. These stars should therefore vary in magnitude from 15.2 to 16.0, or have a mean magnitude of 15.6. For stars south of the equator, one-tenth of a magnitude is subtracted from the magnitudes thus indicated on account of the atmospheric absorption. The fifth column gives the residuals expressed in tenths of a magnitude, found by subtracting the provisional magnitude from that found by the three photometers respectively. Italics indicate that the residuals are negative. When the magnitude depends upon a single instrument an A is inserted. A discordance of a magnitude or more is indicated by a B.

TABLE I.

Des.	Δ α m. s.	Δ δ ′	Prov. Mag.	P W I	Des.	Δ α m. s.	Δ δ ′	Prov. Mag.	P W I
1. γ PEGASI. H. P. 23.				3.0	2. θ CETI. H. P. 220.				3.8
a	2 25	6.0	11.9	. *1* 1	a	4 3	0.7	11.2	. A .
b	2 59	4.5	12.5	. *1* 1	b	4 48	11.0	12.0	. 0 *1*
c	2 37	0.4	13.4	. 0 1	c	3 28	2.9	13.0	. 2 *3*
d	2 49	4.5	13.6	. 0 *1*	d	3 20	0.2	13.0	. *2* 3
e	3 47	2.0	13.9	. 2 *2*	e	3 37	0.7	13.6	. . A
f	3 27	7.5	14.0	. . A	f	2 49	8.1	13.8	. . .
g	2 44	7.0	14.1	. . A	g	3 33	8.5	14.4	. . .
h	3 8	7.5	14.6	. . A	h	3 25	0.1	14.9	. . .
i	3 21	8.0	15.0	. . .	i	3 46	2.7	15.5	. . .
j	3 32	5.7	15.6	. . .	j	3 49	5.0	15.5	. . .
k	3 16	1.3	15.6	. . .					

TABLE I.—*Continued.*

	3. α Piscium.		H. P. 320.	4.0		4. α Ceti.		H. P. 483.	2.7	
a	3 48	7.9	12.0	.*2* 2	a	2 19	7.2	10.9	.*1* 1
b	5 37	1.2	12.0	. 0 0	b	3 37	3.7	10.8	.*2* 2
c	5 33	3.8	13.0	. 1 *1*	c	3 27	6.8	11.8	. 0 *1*
d	4 9	5.6	13.4	. 0 0	d	2 45	7.8	12.9	. 1 *1*
e	2 19	4.1	13.9	. 0 0	e	3 23	1.9	13.2	. 2 *3*
f	2 27	8.0	14.3	. . A	f	5 2	9.6	13.6	. . A
g	2 39	2.0	14.2	. . A	g	5 3	4.8	13.6	. . A
h	5 4	4.1	15.0	. . .	h	4 1	7.0	14.4	. . A
i	5 10	5.2	15.6	. . .	i	3 40	5.5	15.0	. . .
j	3 1	2.2	15.6	. . .	j	3 33	6.1	15.6	. . .
					k	2 25	4.6	15.6	. . .

	5. γ Eridani.		H. P. 653.	3.0		6. α Tauri.		H. P. 707.	1.0	
a	5 38	6.8	9.4	0 *1* .	a	3 59	5.8	9.0	*4 1* 5
b	2 40	8.3	10.7	. *1* 1	b	4 30	6.0	10.0	*6 1* 6
c	5 48	1.7	11.9	. 2 *2*	c	3 5	9.3	11.2	B 0 0
d	5 21	6.2	12.2	. 0 1	d	3 13	10.8	12.0	. . .
e	3 12	0.0	12.4	. 1 *1*	e	3 23	7.0	12.6	. *2* 1
f	3 44	3.0	13.2	. 1 0	f	2 41	1.0	13.1	. *1* 1
g	3 45	2.0	13.4	. . A	g	2 44	7.8	13.6	. *1* 2
h	3 53	0.7	13.8	. . A	h	3 6	2.5	14.0	. . .
i	3 29	5.0	14.9	. . .	i	3 5	4.0	14.5	. . .
j	3 10	5.9	15.0	. . .	j	2 51	6.8	15.0	. . .
k	3 39	6.0	15.0	. . .					

	7. ε Orionis.		H. P. 1029.	1.8		8. γ Geminorum.		H. P. 1249.	2.0	
a	2 1	7.6	6.8	*1* 1 .	a	3 40	5.0	6.4	*2* 3 .
b	2 42	7.7	7.8	1 0 .	b	2 18	3.1	9.5	7 0 7
c	2 52	4.2	8.7	. A .	c	2 24	9.2	11.0	. *2* 1
d	3 7	1.8	10.2	. *2* 2	d	2 39	1.2	11.4	. 0 1
e	3 16	7.8	11.4	. 0 1	e	3 43	3.0	12.0	. 2 *3*
f	2 26	2.2	12.3	. *2* 2	f	3 50	9.0	12.2	. 1 0
g	2 14	4.0	13.3	. 0 0	g	3 1	6.3	12.8	. 3 *3*
h	3 31	6.3	13.3	. . A	h	2 35	3.6	13.7	. 0 0
i	3 49	2.2	14.1	. . A	i	2 47	4.9	13.5	. . A
j	3 40	3.8	14.6	. . A	j	2 32	5.8	13.8	. . A
k	3 49	6.0	15.0	. . .	k	2 34	6.8	14.5	. . .
l	3 21	8.8	15.5	. . .	l	2 41	4.9	15.0	. . .
					m	2 49	7.1	15.1	. . .

TABLE I.—*Continued.*

9. α CAN. MIN. H. P. 1442. 0.5				
a	4 33	0.7	10.3	6 1 7
b	5 56	1.2	10.8	. 3 2
c	2 38	0.2	12.0	. 3 2
d	2 13	3.0	12.0	. 2 2
e	2 55	1.3	12.7	. 1 1
f	2 41	7.8	12.8	. 1 2
g	2 12	6.5	13.8	. . A
h	2 21	4.2	13.9	. . A
i	2 34	2.0	13.8	. . A
j	2 17	1.4	14.4	. . A
k	2 24	2.9	15.0	. . .
l	2 27	5.4	15.6	. . .
m	2 11	7.9	15.6	. . .

10. ε HYDRÆ. H. P. 1608. 3.6				
a	5 23	0.2	9.6	0 1 .
b	5 4	5.0	10.1	2 2 .
c	4 0	1.0	11.3	. 3 3
d	2 49	6.5	11.8	. 1 2
e	2 17	9.0	13.0	. 1 2
f	2 50	2.8	13.0	. 2 1
g	3 25	7.3	13.9	. . A
h	2 41	4.0	14.2	. . A
i	2 29	5.7	14.4	. . A
j	2 48	5.5	15.0	. . .
k	3 18	5.5	15.1	. . .

11. α LEONIS. H. P. 1797. 1.4				
a	3 11	9.0	8.7	. 2 2
b	4 14	10.8	12.0	. 1 2
c	2 16	8.8	12.7	. 0 0
d	2 26	1.8	13.2	. 2 1
e	2 46	4.9	13.2	. 0 1
f	3 10	4.5	13.6	. 1 0
g	2 18	4.5	14.6	. . .
h	2 12	2.5	14.8	. . A
i	2 52	4.5	15.0	. . .
j	2 57	7.2	15.6	. . .
k	2 59	3.0	15.6	. . .

12. θ LEONIS. H. P. 1951. 3.5				
a	2 38	5.7	9.7	1 1 .
b	3 15	6.2	10.8	6 2 9
c	4 1	4.7	11.6	. 2 2
d	2 44	5.8	12.8	. 1 2
e	3 52	5.8	12.8	. 3 3
f	3 44	4.3	13.6	. 2 3
g	2 36	2.1	13.8	. 3 2
h	2 25	6.2	14.2	. . A
i	3 8	2.9	15.0	. . .
j	2 58	3.6	15.6	. . .
k	3 40	5.1	15.6	. . .

13. η VIRGINIS. H. P. 2088. 4.0				
a	2 3	9.3	11.3	. A .
b	5 10	1.8	11.5	. A .
c	4 27	3.5	11.8	. 1 0
d	5 1	7.8	12.6	. 1 0
e	4 25	5.1	12.8	. 1 0
f	5 26	3.2	13.0	. 0 1
g	5 59	3.2	13.9	. 2 2
h	4 38	3.6	14.2	. . A
i	5 54	6.0	14.5	. . .
j	5 33	3.0	14.9	. . .
k	4 49	4.6	15.5	. . .
	5 13	4.2	15.5	. . .

14. α VIRGINIS. H. P. 2263. 1.2				
a	3 24	7.7	10.2	. 1 0
b	2 22	6.8	11.4	. 0 0
c	5 28	9.8	11.4	. 1 1
d	2 51	5.2	12.0	. 2 1
e	3 4	6.0	12.6	. 0 1
f	3 49	7.7	13.1	. 0 0
g	2 12	5.2	13.6	. 1 1
h	2 33	5.4	14.1	. . A
i	2 31	1.9	14.6	. . A
j	2 4	4.0	14.9	. . .
k	2 47	6.4	15.5	. . .
l	2 26	4.2	15.5	. .

TABLE I.—*Continued.*

15. α Bootis. H. P. 2400. 0.0					16. β Libræ. H. P. 2539. 2.7				
a	5 21	0.9	7.2	2 2 .	a	2 7	4.8	9.4	2 1 .
b	4 36	5.2	9.2	2 2 5	b	3 36	6.0	10.1	2 2 .
c	6 6	1.3	10.4	. 2 2	c	2 41	8.8	11.0	. 8 8
d	5 31	6.3	11.8	. 3 2	d	3 47	6.1	12.0	. 1 1
e	3 59	3.2	12.2	. 1 2	e	3 23	2.8	12.8	. 1 1
f	3 36	1.5	12.8	. 0 1	f	2 25	1.0	13.3	. 2 2
g	3 24	0.5	13.9	. . A	g	2 19	3.9	14.9	. . A
h	3 0	8.3	14.7	. . .	h	2 22	6.4	14.9	. . .
i	3 2	6.4	15.0	. . .	i	2 18	7.4	15.0	. . .
j	4 27	5.5	15.6	. . .	j	2 25	4.4	15.5	. . .
k	5 43	5.0	15.6	. . .					

17. δ Ophiuchi. H. P. 2726. 2.8					18. η Ophiuchi. H. P. 2868. 2.6				
a	2 57	0.0	10.6	0 0 1	a	3 8	10.5	9.3	B 4 7
b	5 40	9.6	10.7	. . A	b	2 52	1.0	11.8	. 4 5
c	2 51	6.6	12.0	. 0 1	c	2 14	4.3	12.3	. 4 4
d	3 0	4.3	12.7	. 2 2	d	3 7	8.1	13.1	. 2 2
e]	2 54	3.5	13.4	. 0 1	e	3 45	8.0	13.6	. 2 1
f	2 40	3.5	14.1	. . A	f	2 0	1.5	13.8	. 0 1
g	2 40	4.5	14.9	. . A	g	2 9	7.3	14.2	. . A
h	2 32	5.7	14.9	. . .	h	2 42	2.0	14.3	. . A
i	2 21	6.2	15.5	. . .	i	2 45	7.2	14.5	. . A
j	3 10	6.9	15.5	. . .	j	2 38	6.0	15.0	. . A
					k	2 33	4.1	15.0	. . .
					l	2 28	5.3	15.5	. . .

19. η Serpentis. H. P. 3090. 3.4					20. δ Aquilæ. H. P. 3343. 3.5				
a	5 0	3.6	9.7	1 1 .	a	4 2	3.0	8.2	2 1 .
b	3 42	8.8	11.8	. 0 1	b	3 23	8.8	9.0	1 0 .
c	4 36	5.0	12.4	. 0 0	c	5 20	6.0	11.2	. 5 4
d	2 33	6.5	13.0	. 2 2	d	4 6	8.5	11.1	. 1 1
e	3 16	0.5	13.0	. 1 2	e	2 46	4.0	11.5	. 1 1
f	5 18	5.2	14.2	. . A	f	2 35	2.8	12.4	. 1 0
g	4 46	5.0	15.6	. . A	g	2 17	4.8	12.6	. . A
h	4 24	8.4	15.0	. . .	h	2 23	3.0	13.3	. . A
i	5 4	8.5	15.5	. . .	i	2 56	2.6	13.3	. . A
					j	2 32	4.5	14.6	. . A
					k	2 27	3.5	14.9	. . A
					l	2 47	2.5	15.1	. . .
					m	3 23	6.8	15.1	. . .

TABLE I.—*Continued.*

21. θ AQUILÆ. H.P. 3514. 3.4					22. β AQUARII. H.P. 3795. 3.1				
a	2 42	1.8	8.1	22.	a	2 21	10.1	9.5	.A.
b	3 10	6.0	10.3	515	b	4 0	2.0	11.9	.11
c	3 22	1.8	11.4	.33	c	2 52	8.4	12.4	.01
d	4 3	2.2	12.0	.43	d	4 19	1.0	12.9	.00
e	2 9	0.8	13.2	.43	e	4 9	8.1	13.2	.12
f	2 14	7.5	13.4	.43	f	3 6	6.9	13.4	..A
g	2 55	3.8	13.7	..A	g	3 32	7.7	13.8	..A
h	2 21	6.5	14.0	..A	h	3 54	6.0	14.0	..A
i	2 8	4.0	14.4	..A	i	2 59	2.5	14.9	..A
j	2 15	6.0	14.9	..A	j	3 12	3.2	14.9	...
k	2 23	4.5	15.2	..A	k	3 40	5.5	15.1	...
l	2 26	7.5	15.5	...	l	2 59	7.7	15.5	...
m	2 29	2.7	15.5	...	m	2 34	7.5	15.5	...

23. α AQUARII. H. P. 3899. 3.2					24. α PEGASI. H. P. 4080. 2.6				
a	6 10	2.9	9.3	.A.	a	4 56	5.0	9.9	.A.
b	3 21	2.2	12.5	.00	b	2 32	8.7	10.5	.A.
c	2 49	5.9	12.9	.00	c	3 23	9.3	11.6	.10
d	3 45	1.4	13.0	.10	d	1 54	8.3	12.1	.A.
e	2 20	2.8	13.7	..A	e	3 38	9.3	13.3	.11
f	3 6	5.4	14.2	..A	f	3 20	6.0	14.3	..A
g	2 27	4.1	14.7	..A	g	2 31	3.8	14.6	..A
h	2 9	3.4	15.1	..A	h	2 18	1.0	15.2	..A
i	2 14	4.9	15.0	...	i	2 34	2.0	15.0	...
j	2 40	3.2	15.0	...	j	3 30	5.3	15.1	...
k	3 22	6.2	15.5	...	k	3 1	5.7	15.6	...

An additional series of standards is contained in Table II. This consists of stars in the immediate vicinity of the North pole. The selection is that recommended in a circular issued by the Harvard Observatory in 1879. See also *Astron. Nach.*, XCV, 29, *Nature*, XX, 14, *Astron. Reg.*, XVII, 175. These stars afford a convenient means of insuring uniformity of scale throughout the

Report of the committee on indexing chemical literature.

Dr. H. Carrington Bolton, reporter.

The Committee on Indexing Chemical Literature respectfully present to the Chemical Section their third annual report.

Five hundred copies of our report for 1884 have been sent to chemists throughout the United States, the distribution having been made through the Smithsonian Institution without expense to the committee; the report was also published in the chemical News (London), and favorably noticed in the American Library Journal (New York). This wide circulation led to many applications for single indexes and for sets, which were filled as far as possible either by the chairman or by Professor D. S. Martin, editor of the Annals of the New York Academy of Sciences, in which serial most of the indexes were published.

But one offer of assistance in the scheme of coöperative indexing has been received during the year.

Dr. F. E. Engelhardt offers to undertake an Index to the Literature of Common Salt.

Reports of progress have been received from several gentlemen: Professor Wm. Ripley Nichols, on Carbon Monoxide; Professor L. P. Kennicutt, on Meteorites; Professor C. E. Monroe, on Explosives.

During the year Dr. H. Carrington Bolton has published in the Annals of the New York Academy of Sciences a Catalogue of Chemical Periodicals (58 pp., 8vo, New York, 1885). This embraces 182 titles in several languages, and is intended to form an authoritative list of all the completed and existing periodicals devoted to chemistry, with a view to facilitating the researches of those undertaking the compilation of indexes.

Dr. Bolton has also completed the second Index to the Literature of Uranium mentioned in our preceding report; this index has been examined by the committee, accepted and transmitted to the Smithsonian Institution for publication, in accordance with the agreement entered into by the secretary Professor S. F. Baird. Its early publication may be expected.

The committee deem it part of their duty to chronicle the publication of chemical indexes and bibliographies which may be is-

sued independently, and which fall under their notice. They therefore call attention to the following:

List of Tests (Reagents), by Hans Wilder. New York and London. 88 pp. 12mo, 1885.

This is a useful little brochure containing a list of nearly 900 chemical tests known by the names of their authors, arranged alphabetically by authors, and provided with a full index of subjects. It can be obtained of Professor P. W. Bedford, 5 Beekman St., New York.

In conclusion, the committee appeal for support to the chemists in whose hands this report may fall; they call for volunteers to undertake indexes to special topics in chemical literature, and especially to the elementary substances. The indexes and bibliographies now on their list number fifteen; cannot this number be soon doubled? The committee does not dictate to independent workers a fixed plan, but leaves method and subject to the authors; the committee does not seek to control the productions further than to insure work of high merit and to guard the interests of the Smithsonian Institution which has agreed to publish manuscripts endorsed by the committee. Chemists willing to undertake the compilation of indexes are requested to send their names and addresses with a memorandum of the subject chosen, to the chairman of the committee (care of the Smithsonian Institution) who will furnish sample copies of indexes already in print and other desired information.

Respectfully submitted,

H. CARRINGTON BOLTON, *Chairman.*
IRA REMSEN,
F. W. CLARKE,
ALBERT R. LEEDS,
ALEXIS A. JULIEN,
Committee.

August 19, 1885.

APPENDIX TO REPORT OF COMMITTEE ON INDEXING CHEMICAL LITERATURE.

Washington, D. C., October 24, 1884.

Prof. H. CARRINGTON BOLTON, Ph.D.,

Chairman of the Committee on Indexing Chemical Elements, A.A.A.S.,

Sir:—

In response to your request for a statement of my method of indexing scientific literature, I have the honor herewith to transmit an account of my plan, and its leading features as I have discovered them by use.

Very respectfully,

WM. FREAR.

A METHOD OF INDEXING SCIENTIFIC LITERATURE. By PROFESSOR WM. FREAR.

FOR several years it has been my custom to index the most important papers bearing on problems in which I have, from time to time, been interested. After some experience with different methods of indexing, I have finally devised a plan which meets the demands of my own work more fully than any other method I have tried.

In the formation of this plan, the following data have had weight:

1. Information concerning subject-matter, or authorship, is much more frequently sought, than concerning points of chronology, and when historical data *are* the objects of search, there is much more probability that they relate to minor details of a subject, than to the general class of matter indexed under a bibliographic title.

2. When a given paper is being sought, the clew to its position is probably the name of the author, or the nature of the subject matter, and rarely the date of its reading or publication.

3. To relieve any who may in the future attempt to collate the bibliographies compiled by different individuals, from the necessity of a comparison of every item with the original paper indicated, an index should contain in compact form all distinctive data necessary to a complete knowledge of the subject-nature, and the biographical and historical relations of each paper indexed.

4. Utility, while demanding completeness, will neither allow the space necessary to the full answer of every *form* of query on a given minor subject, nor, on the other hand, a complex system of cross-reference.

In consideration of these facts, the following system was reached:

It involves both an author and a subject-index. In the author-index are given the following data:

1. The full name of the author.

2. The date of the reading of the paper, or if that is not available, the date of publication.

3. The *original* title.

4. If that is not sufficiently specific, a brief emendation added in brackets.

5. The volume and page of the periodical in which the paper first appeared, followed by a list of the places where abstracts are found.

The index of authors is in alphabetical order; while the different papers written by the same author are arranged in chronological order under his name.

The titles in the subject-index are made up from a consideration of the specific subject-matter of a paper, rather than from its title; the arrangement is alphabetical, just like any ordinary subject-index, but references are made under the subdivisions of each specific title to the *authors* who have written on the subject indicated by that particular subdivision, followed by the *date* of the paper given in the author-index. Under each subdivision, the names of the authors occur in alphabetical order.

To illustrate, take the article appearing in the Journal of the Chemical Society of London, Volume 23, page 371, detailing the discovery of butyric ferment in water contaminated by sewage, and entitled Organic Matter in Water, by Charles Heisch, Lecturer, etc. Reference to the Proceedings of the Society shows it to have been read on June 16, 1870.

The author-index would have the following entry:

Heisch, Charles
1870, June 16.
On Organic Matter in Water.
[Occurrence of *butyric ferment* introduced by sewage contamination.]
J. Ch. Soc. 23, 27.

List of Abstracts }

In the subject-index the following entries would be made:

1). Butyric Ferment.
Occurrence in water contaminated by sewage.
Heisch, C., 1870, June 16.

2). Water,
Contaminated by sewage. Occurrence of butyric ferment in.
Heisch, C., 1870, June 16.

By the use of this plan the following advantages are gained:

1. A ready reference to any paper, given a knowledge of its authorship or subject.

2. A general idea of the lines of investigation already opened up, relating to any specific subject, from a glance at the subject-index.

3. A knowledge of what any author has written on the subject proper

of the bibliography, and in what chronological order, from a glance at the author-index.

4. A ready access to the history of any detail of a specific subject by reason of the relatively small number of references under the proper subdivision, and the use of dates in connection with those references in the subject-index.

5. A possibility of great expansion of the subject-index with the requirements of only a small additional amount of space, and without complexity of cross-reference.

6. The compact arrangement in the author-index, of all data necessary to the distinctive knowledge of an article.

It may seem that an indication of the *locus* of a paper might with advantage be appended to the date in the subject-index, but a consideration of the multitude of abstracts will show immediately the reason for the omission.

Again, it may be urged that the first of the principles announced as the basis of the system—viz.: the paramount importance of subject and authorship, would require a subject-classification of the papers under the name of a given author, rather than the chronological order which is adopted. An attempt to arrange according to the *original* titles will soon be found untrustworthy; an arrangement according to *emended* titles is found to interfere with the ready grasp of the details which are presented in the author-index, and are its marked features.

Finally, it may be objected that an index, prepared according to this system, suffers from the disadvantage of being at best, much more bulky, than those prepared according to other plans which have been proposed; thus involving both greater labor in preparation, and increased expense in publication. In reply to these objections, attention must be called to the fact that the mere labor of *writing* an index is very small, relative to that expended in finding *what* to write, and that the latter factor is a constant, whatever plan be adopted, and second, that though the cost of publication be slightly greater, the greatly increased completeness and utility far outweigh this difference in cost.

First report of the committee on an international scientific congress. Dr. Charles Sedgwick Minot, reporter.

The Committee has conducted an extensive correspondence and made considerable progress. The question of the propriety of attempting an International Meeting in London is now before the British Association, and our further action must depend upon their decision, which cannot be reached until September during the meeting at Aberdeen. We are not at liberty to publish the correspondence, but your Committee feel that much progress has been made in the matter under their charge, and it seems not improbable that the first International Scientific Congress may be held at London within a few years.

An endowment has already been secured owing to the renewed munificent liberality of Mrs. Elizabeth Thompson of Stamford, Conn., who through Dr. Charles S. Minot has placed a sum of twenty-five thousand dollars in the hands of a board of Trustees, the income to be expended "for the promotion of pure science in the broadest sense" by the International Congress, when satisfactorily organized. For this assistance to our enterprise, Mrs. Thompson deserves the hearty thanks of our Association. A fuller account of this very noble gift will be found in Science of Aug. 21, 1885.

Respectfully submitted,

Simon Newcomb,
T. Sterry Hunt,
G. F. Barker,
J. W. Powell,
E. C. Pickering,
Ira Remsen,
Charles Sedgwick Minot,
Committee.

First report of the committee on the encouragement of researches on the health and diseases of plants. Prof. J. C. Arthur, reporter.

The committee appointed at the last meeting of this Association decided upon consultation that the most important work to be accomplished was to secure first a hearing from the authorities of the Department of Agriculture at Washington, and to urge the establishment of a Bureau or Division in that Department for the study of plant diseases, especially those produced by fungi. Accordingly, the following memorial was addressed to the commissioner, Hon. N. J. Colman, in April of this year, signed by six members of the committee.

To the Honorable Commissioner of Agriculture, Washington, D. C.

Dear Sir:—

The undersigned were appointed a committee by the American Association for the Advancement of Science during its meeting in Philadelphia, September, 1884, for the purpose of calling the attention of the Department of Agriculture to the needs of proper investigation into the diseases of plants.

We would therefore respectfully urge that in planning the work of the Department for the coming years, you make provision for a thorough scientific study of the diseases of plants, especially those due to the parasitic fungi, believing that by so doing you will greatly increase the efficiency and value of the Department.

We would urge further that in the appointment of an officer to make such investigations you select a man whose training has been such as to enable him to call to his aid all the knowledge and appliances of the best modern scientific methods.

Respectfully submitted,

(Signed) J. C. Arthur, *Chairman*,
C. E. Bessey,
T. J. Burrill,
J. T. Rothrock,
W. J. Beal,
C. H. Peck,
Committee.

The Commissioner replied with promptness, stating his hearty sympathy with the objects of the committee and offering all the aid in his power to further them. He also stated that he had appointed Mr. F. L. Scribner of Girard College, Philadelphia, to take charge of such work for the department.

In order to show the good will of the committee toward Mr. Scribner and the work which he had now undertaken the following communication was then sent to him.

To Prof. F. L. Scribner, Assistant Botanist Department of Agriculture, Washington, D. C.

Dear Sir:—

The committee appointed by the American Association for the Advancement of Science to encourage researches on the health and diseases of plants are much gratified to learn that they have the hearty sympathy of the Commissioner of Agriculture in regard to this line of investigation and that it is substantially shown in your appointment to carry on such work as a part of the regular duties of the Department. The Committee desire to express the hope that you will lay as broad foundations for future work as the great importance of the subject demands and the facilities at command will permit. Investigations of this nature are for the most part difficult and consequently slow of results, but the advancement made should be sure and valuable. As much of the work already accomplished in this field has been done by German investigators and the results rarely accessible to those who do not read that language, much good could be accomplished by including in your reports among other things papers upon the present state of our knowledge regarding such diseases as you may select with citation of literature.

Quite a number of communications have been exchanged between members of the Committee and Commissioner Colman and Mr. Scribner in relation to the work of the Department in this direction. The efforts of the Committee have resulted in bringing about the most harmonious relations between them and the Department of Agriculture, and in the establishment of a Section of Mycology of the Division of Botany for the investigation of plant diseases which promises to become of much scientific and economic value to the country at large.

It is the desire of this Committee to still further aid the De-

partment of Agriculture in establishing this new work upon a solid and broad basis.

Respectfully submitted,

J. C. ARTHUR, *Chairman.*
C. E. BESSEY,
W. G. FARLOW,
T. J. BURRILL,
J. T. ROTHROCK,
W. J. BEAL,
C. H. PECK,
Committee.

First report of committee in relation to the transmission of botanical specimens through the mails. Prof. Lester F. Ward, reporter.

The undersigned members of the committee appointed by the Section to urge the amendment of the laws so as to secure the transmission of botanical specimens accompanied by written labels at fourth-class rates of postage, respectfully report that we waited upon the Postmaster-general and laid the matter before him with full explanations and received assurances that it would receive favorable consideration; that as a result of this action of the committee the Postmaster General did make the desired recommendation to Congress, which may be found on page 15 of his Annual Report for the fiscal year 1883-'84; that the matter was properly brought before the Postal Committee, but that owing to the rush of business at the close of the session the clause embodying this provision did not find its way into the appropriation bill, which was not passed until the closing hours of the session. The committee has further taken the liberty to call the attention of the present Postmaster-general to the recommendation of his predecessor and to urge its renewal by him in his report the present year, and there is little doubt that this will be done.

Should the Association see fit to continue this committee, nothing will be left undone to consummate the desired change, which seems to meet with no active opposition from any quarter, and the coming session being a long one it is believed that the object can be accomplished during the next session of Congress.

Respectfully submitted,

Lester F. Ward,
Geo. Vasey,
J. W. Chickering,

Committee.

SECTION A.

MATHEMATICS AND ASTRONOMY.

PAPERS READ.

On the effect upon the earth's velocity produced by small bodies passing near the earth. By Prof. H. A. Newton, Yale College, New Haven, Ct.

[ABSTRACT.]

The reasoning in the paper shows that there is a real effect upon the motion of a planet due to the attraction of gravitation between small bodies and the planets, although that effect is much too small to be detected by observation.

The following theorems are established.

A. If a cylindrical stream of small bodies evenly distributed and all moving in the same direction with common velocity shall move past the earth supposed to be in the axis of the cylinder, the small bodies by the law of universal gravitation shall communicate to the earth a velocity along the axis in each unit of time:

(1) That shall be proportional to the density of the group:

(2) That shall decrease as the velocity increases varying very nearly inversely as the square of the velocity:

(3) That shall increase with the radius of the cylinder, and shall be proportional to the logarithm of that radius, measured by a unit that differs from the earth's radius by a small quantity which is a function of the velocity.

Strictly taken, if the cylinder have an infinite radius the velocity communicated is also infinite; but if the radius be comparable with measurable stellar distances, the velocity communicated is not large.

B. If a widely extended group of small bodies evenly distributed through space have absolute velocities all equal to each other but directed towards points evenly distributed over the surface of the celestial sphere, and if the earth moves in a right line through them:

(1) A portion of the bodies will come into the earth's atmosphere and affect the earth's motion in the manner of a direct collision;

(2) The rest will pass by and exert only an effect by reason of gravitation.

If the earth's velocity be *less than that of the bodies*, the total effect of the action of the bodies of this second class upon the earth's motion will be an exceedingly minute acceleration of the earth's motion, even though the extent of the group is infinite. The outer limit of the group, when large, disappears from the formula that expresses the acceleration.

If, however, the earth's velocity be *greater than that of the bodies* the total effect of the action of the bodies of this second class upon the earth's motion will consist of two parts:

First, a very minute retardation of the earth's motion, depending for its amount upon the absolute velocity of the bodies;

Second, a retardation of the earth dependent for its amount upon the assumed extent of the group. If the action of those bodies which would pass nearer to the earth than a distance P be considered, this second part of the action is proportional to the logarithm of P.

C. The action of the bodies of the first class is manifold greater than that of the bodies of the second class. And since any admissible magnitude of meteoroids would make the effect which those which strike the moon exert upon the acceleration of the moon's mean motion only an exceedingly minute fraction of the moon's observed acceleration, still less can the action of the meteoroids passing near the moon have any measurable effect.

ON THE FLEXURE OF TRANSIT INSTRUMENTS. BY WM. HARKNESS, U. S. Naval Observatory, Washington, D. C.

[ABSTRACT.]

THE author showed that

$$F = \varphi(\zeta) + \Psi(\zeta). \qquad (1)$$

in which F is the correction for flexure to the line of collimation when the zenith distance of the latter is ζ, and $\varphi(\zeta)$ and $\Psi(\zeta)$ are two undetermined functions of the zenith distance, the generality of which will not be impaired if both are assumed to be of the form

$$a_1 \sin \zeta + b_1 \cos \zeta + a_2 \sin 2\zeta + b_2 \cos 2\zeta + \text{etc.} \qquad (2)$$

By dropping from (2) such terms as must vanish in order that

$\varphi(\zeta)$ and $\Psi(\zeta)$ may fulfil certain necessary conditions, the latter functions take the forms

$$\varphi(\zeta) = \pm b_1 \cos \zeta \pm a_2 \sin 2\zeta \pm a_3 \sin 3\zeta \pm, \text{ etc.} \quad (3)$$

$$\Psi(\zeta) = a^{ii} \sin 2\zeta + a^{iv} \sin 4\zeta + a^{vi} \sin 6\zeta + \text{etc.} \quad (4)$$

Then from (1), (3) and (4)

$$F = \pm b_1 \cos \zeta + (a^{ii} \pm a_2) \sin 2\zeta \pm a_3 \sin 3\zeta + (a^{iv} \pm a_4) \sin 4\zeta \pm a_5 \sin 5\zeta + \text{etc.} \quad (5)$$

where the upper signs must be taken when the clamp is west, and the lower when it is east.

It is probable that in practice the first two terms of (5) will suffice to give F with all desirable accuracy; and if so, b_1, a_2 and a^{ii} are the only coefficients which demand attention. The method of determining the values of b_1, and a_2 was explained, and then the results of the discussion were summed up as follows:

1.—The sole condition capable of insuring the rigorous perpendicularity of the line of collimation to the axis is that the reversal of the telescope shall not affect the action of gravity upon any of its parts. This condition is fulfilled only when the telescope is pointed either to the zenith or to the nadir, and for any other position the line of collimation is not in general perpendicular to the axis.

2.—For the zenith distance at which it was determined, the line of collimation possesses the essential properties of a line perpendicular to the axis in so far that its direction is unaffected by reversing the telescope, and if it coincides with the meridian on one side of the zenith, it will also coincide with it at the same altitude on the other side of the zenith, provided no error of level exists.

3.—The flexure is made up of two parts, $\varphi(\zeta)$ and $\psi(\zeta)$. The numerical coefficients in $\varphi(\zeta)$ can readily be determined from observations upon two collimators; but that process fails completely for the coefficients in $\psi(\zeta)$, and the only way of estimating them seems to be by star transits reduced upon the assumption that the star places are rigorously accurate.

4.—The correction for flexure can be thrown upon either the azimuth, the level, or the collimation, as may suit the convenience of the computer.

5.—When the flexure can be expressed by a single term, it is generally most convenient to throw the correction for it upon the level. The corresponding collimation constant will then belong to the horizontal position of the telescope.

6.—When the expression for flexure consists of two or more terms, it is best to throw the correction for it upon the collimation. The constant part of the latter will then be its value for the horizontal position of the telescope.

DESCRIPTION OF A PRINTING CHRONOGRAPH. By Prof. G. W. HOUGH, Director of the Dearborn Observatory.

ABOUT the year 1848, the idea of recording astronomical observations by the use of galvanic electricity was put in successful operation by different individuals. Since that time chronographs of various forms have been constructed for recording in a legible manner on a moving sheet of paper the time of any phenomena observed. The great simplicity, in point of accuracy and saving of labor over the eye and ear method formerly used, led to the almost general adoption of the new plan.

Notwithstanding the great value of the recording chronograph, the large amount of labor involved in the conversion of the records into numbers, early led astronomers to consider the feasibility of an instrument which should at once print with type the time of the observation.

From a casual consideration of the subject it might, at first sight, appear to be an easy matter to substitute type wheels in place of the revolving cylinder of an ordinary chronograph, from which impressions could be taken, but when we attempt the practical construction of such an apparatus many difficulties are met, which were not before suspected.

The construction of any form of printing chronograph is a problem of great difficulty, and will require a good deal of experimental work on the part of the inventor; at least such has been my experience. In the year 1871, I constructed a printing chronograph at the Dudley Observatory which was in constant use for a period of three years. This machine, although somewhat cumbersome, was eminently successful, both in point of accuracy and reliability; the probable error of a single impression being $0.^{sec.}013$. The type wheels, however, were somewhat troublesome to keep in order, as they were made by soldering electrotype strips of copper on brass disks and required renewal once a year or oftener.

In the construction of the present machine I have followed my

former method in the general design of the apparatus, but have in many respects modified the mechanical construction of its different parts.

For a clear understanding of the mechanism, elaborate drawings would be necessary; I shall, therefore, merely give a general account of its construction and peculiarities.

The machine consists of: first, a system of clockwork carrying a type-wheel with fifty numbers on its rim, revolving once every second, one, two, or parts of two numbers being always printed, so that hundredths of seconds may be indicated. This train is primarily regulated to move uniformly by the Frauenhofer friction balls, and secondarily, by an electro-magnet acting on the fast-running type-wheel and controlled by the standard clock. This train is entirely independent and can be stopped at pleasure without interfering with the other type-wheels. Second, a system of clockwork consisting of three or more shafts carrying type-wheels indicating minutes and seconds. The motion of this train is also governed by an electro-magnet controlled by the standard clock, operating an escapement in a manner analogous to the action of an ordinary clock; every motion of the escapement advancing the type one number.

There are three type-wheels indicating minutes, seconds and hundredths of seconds. The integer seconds are advanced at every oscillation of the sidereal clock pendulum; and the minute, at the end of each complete revolution of the seconds wheel.

In front of the type-wheels is placed a spool of paper, two inches in width, which is passed over the tops of the type and drawn between two brass rollers. Behind the type-wheels inking rollers rest lightly against their rims. Just behind the paper spool is a large electro-magnet of one ohm resistance, the armature of which carries three flexible arms to which the hammers are attached for making the impression. The fillet of paper, in passing over the type-wheels, is supported on a stage and held above the type. When the armature of the printing magnet is pressed gently down, the hammers stand about one-half inch away from the type; the impression being made from the vibration of the arm and not by a direct blow. In the act of printing none of the type-wheels are stopped, the impressions, therefore, may follow each other as rapidly as the electro-magnet can be operated. If the impression is made when the integer second is in the act of changing, parts of

two numbers are printed. In case the hundredths read ninety-six to ninety-eight, the smallest seconds is the correct one. There is no ambiguity. The fillet of paper is advanced one-third inch whenever an impression is made, and by the use of a duplicate key, it may be advanced at any time so as to leave a blank space of any desired amount between the records for different stars.

In the present machine the types were engraved on solid brass wheels which were previously spaced on a gear cutter. The types are inked by means of small wooden rollers covered with cloth and resting against their rims; when the machine is in regular use fresh ink is necessary about once in two days, or impression ribbon may be used. The type-wheels are readily set to indicate the time of the standard clock, the time necessary for this operation being about two minutes. For regular meridian work, the type may be set for integer seconds of mean R. A. which saves the trouble of carrying a large clock error through all the successive steps of reduction. In my former machine the blow for printing was done by a hammer which was elevated by a heavy train of clock work. In the present machine this clock work is dispensed with, the blow being delivered directly by an electro-magnet. The invention of the storage battery has made this method practicable which before was not. I use three storage cells, each having an electro-motive force of two, and a resistance of 0.3 to 0.4 ohms, being about the equivalent of an ordinary Grove; all these cells are charged by eight small gravity elements having a resistance of from seven to ten ohms each, depending on the condition of the battery. By charging the storage cells separately, three ordinary gravity elements would be sufficient. The small gravity battery is kept constantly connected with the storage cells, all being arranged in series, so that the connections with the chronograph and other apparatus need not be disturbed.

The printing chronograph is eminently a labor-saving machine. Any one who possesses such an apparatus will find it a luxury to make transit observations, since one is saved the mechanical drudgery of reading off and copying the record sheets.

In any observatory where systematic meridian work is done, I presume the cost of reading off and copying the chronograph sheets would amount to at least one thousand dollars annually. A large proportion of this outlay can be saved by the use of a printing instrument.

ON A RARE SUN-SPOT OBSERVED MAY 19, 21, 22, 1885. By Prof. DAVID P. TODD, Lawrence Observatory, Amherst, Mass.

THE AUDIBLE CIRCLE; A NEW DEVICE WHEREB THE SETTINGS OF AN ASTRONOMICAL INSTRUMENT MAY BE MADE BY THE EAR. By Prof. D. P. TODD, Lawrence Observatory, Amherst, Mass.

THE VISIBLE SHADOW OF THE EARTH. By Prof. JOHN HAYWOOD, Otterbein University, Westerville, Ohio.

RAPIDITY OF CALCULATION AS INCREASED BY THE AVOIDANCE OF REPETITION, AND THE USE OF MENTAL PROCESSES INSTEAD OF WRITTEN. By STEPHEN S. HAIGHT, C. E., West Farms, N. Y.

PARALLAX OF THE SUN. By THOMAS BASSNETT, Jacksonville, Fla.

POLAR VERSUS OTHER COÖRDINATES. By Prof. J. BURKITT WEBB, Stevens Institute of Technology, Hoboken, N. J.

SOME PRACTICAL RESULTS IN DETERMINING TIME AND LATITUDE WITH THE ALMUCANTAR. By Prof. CHARLES H. ROCKWELL, Tarrytown, N. Y.

SECTION B.

PHYSICS.

PAPERS READ.

Observations on invisible heat-spectra and the recognition of hitherto unmeasured wave-lengths, made at the Allegheny Observatory. By Prof. S. P. Langley, Allegheny, Pa.

It is known to all, that the surface temperature of this planet depends upon the properties of radiant heat and the relation to them of the action of its atmosphere. It has been usual to compare this action to that of the glass cover of a hot-bed; for glass it is also well known, grows opaque to dark heat, and continuously so, as its wave-length increases, thus letting the solar light-heat pass freely through it to the soil, while it is comparatively impervious to the dark heat returned from the latter; but this analogy must not be interpreted too literally. Whether the atmosphere is pervious to the soil's heat we do not here discuss, but it has of late[1] been shown that the air does not behave otherwise like glass as it was supposed to do, but grows,—not more opaque—but more transmissible, to *solar* heat, up to its greatest observed wave-length, and that hence our views of the nature of the yet uncomprehended heat-storing action which maintains organic life on the earth must be modified. The little that the spectroscope tells us about the atmospheres of other planets, leads us to think that we can best understand their relations to solar energy by studying the atmosphere of our own; for our non-comprehension of these relations is largely due to our ignorance of certain physical data which have never yet been obtained.

It is thus that the present research, though belonging to a department of astronomical science, depends so much on the solution of certain physical problems, that I cannot regret that it has been referred to this section, or that it is chiefly to an audience of physicists that I have the opportunity to submit it.

While the general question for the physical astronomer then, is "What kind of transformation does the solar energy suffer at the

[1] See Professional Papers of U. S. Signal Service, No. 15, Expedition to Mount Whitney.

surface of any planet?" we here seek a reply to the simpler preliminary one "What are the wave-lengths of heat from non-luminous sources, such as the soil of this planet?" a question which has never been answered, because there have been no means of recognizing this heat when drawn out into a spectrum; indeed we so habitually associate the idea of a spectrum with that of light, that there is a certain strangeness, at first in the idea even, of a "spectrum" formed by a cold body like, for instance, ice. Yet the ice surface must not only be capable of radiating heat to a still colder body, but according to our present conceptions of radiant energy, be capable of giving a spectrum, whether we can recognize it or not. It is the object of the present paper to describe the actual formation of such spectra, and the recognition of their heat in approximate terms of wave-lengths.

To distinguish between these new regions of research and the older ones, let us briefly summarize our actual information about wave-lengths, since on the latter the whole question largely turns, and each extension of it, we may agree, is a step toward an interpretation of everything about the constitution of the universe which radiant energy may have to tell us. Thus there is no exact relation known between the periods of vibration of certain molecules in the sun and the angles through which the rays announcing them, are refracted by a prism, while the wave-lengths of these rays, if known, are capable of giving us quite other intelligence.

Yet our knowledge even of the wave-lengths of light is comparatively recent, since it was only at the beginning of this century that the labors of Thomas Young brought the undulatory theory itself from the disfavor in which it had lain, and the memoirs in which Fraunhofer gave the first relatively full and accurate measures of the wave-lengths of light date no farther back than 1814.

The measures of Newton, interpreted in terms of the present theory, gave the length of the extreme violet waves at $\frac{1}{10,000,000}$ of an inch, and of the extreme red at $\frac{1}{10,000,000}$, or in millimetres 0.00042 mm. and 0.00067 mm. respectively, numbers nearly corresponding with the lines H and B, while Fraunhofer's own values are comprised between 0.00036 mm. and 0.00075 mm. More recently the range of vision has been still more extended, by the use of the fluorescent eyepiece of Soret, while by the aid of photography and the employment of quartz trains, solar radiations of a

wave-length of about 0.29 μ have been observed,[2] and rays whose wave-length is as little as 0.185 μ have, it is said, been observed from the induction spark.

Our atmosphere cuts off the ultra violet rays of a length less than about 0.29 μ, while I have found it not very difficult to *see* below Fraunhofer's great A, lines whose wave-length is about 0.81 μ. The extreme range of the normal eye then, is from about 0.00036 to 0.00081 mm. or a little over one octave, though the statement that the range of the eye is less than one octave is still commonly made.

Fraunhofer's first measures were made with a literal grating composed of parallel strands of wire, while the successive labors of Nobert, Rutherfurd and Rowland have placed in the hands of physicists instruments of constantly increasing power, which have finally reached what seems nearly theoretical perfection at the hands of the two latter. It is with the now so well known gratings of Professor Rowland that the direct measures of wave-lengths in the solar heat spectrum I have already made public[3] have been chiefly executed.

In Plate 1 we have a necessarily condensed representation of the whole spectrum, visible and invisible, on the normal scale, the distances being proportional to the wave-lengths observed. The inferior limit being 0, we have at (*a*) the number 0.18 μ (eighteen one-hundred thousandths of a millimetre) which represents the shortest measured in the electric spark from aluminum. Next near 0.29 μ (*b*) we have, according to M. Cornu, the shortest solar ray which penetrates our atmosphere; near 0.35 μ (*c*), in the ultra violet, is the shortest wave which can be seen by the naked eye, and nearly the shortest which can pass through glass, while near 0.81 μ (*d*) in the extreme red, is nearly the longest which the eye can observe. The entire visible spectrum on the normal scale is, it will be seen, insignificant in comparison with that great infra-red region which is so important to us, and of which we know so very little. It has been known since the time of the first Herschel that heat rays existed below the range of vision, but of their wave-lengths nearly nothing has, till lately, been ascertained, partly for want of sufficiently delicate heat-recognizing apparatus, and still

[2] (1.0 μ = 0.001 mm.)

[3] National Academy of Science, 1883. Am. Jour. of Science, March, 1884.

more from the fact that it is difficult to use the grating here, owing to the overlapping spectra, and to the consequent necessity we have till lately been under, of separating these rays only by the prism, which gives no measure of their wave-lengths. Physicists have accordingly attempted to find these, by observing what deviations correspond to known wave-lengths in the visible portion, and by trying to determine from theoretical considerations, what relations should obtain in the infra-red, but the various formulæ by which these supposed relations have been expressed have not till lately been tested. The difficulty has been partly overcome in the last few years, by the application of the linear bolometer to the spectrum formed by the concave gratings with which Professor Rowland has furnished us; the deviations of the heat rays having first been observed and the principal lines of the infra-red region mapped by the joint use of the bolometer and a flint glass prism, in 1881. It will be remembered that one of the best known formulæ on which physicists till lately relied for determining the relations of wave-lengths to deviations was Cauchy's; that this set an absolute limit to the wave-length which any prism could under any circumstances discriminate, and that this supposed extreme wave-length was somewhere between 10,000 and 15,000 on Angstrom's scale. Besides this theoretical limit, it was supposed that glass absorbed dark heat, to such an extent, that the longer solar heat waves would be stopped in the substance of the prism, even were there no other obstacle.

In 1881, however, we found at Allegheny by actual trial, that heat waves whose wave-length was far in excess of the theoretical limit, passed through a flint glass prism, so that it was ascertained that common glass was nearly diathermanous to all the dark heat which comes to us from the sun. By means of a glass prism and the bolometer, we were thus able to pursue our researches and map the infra-red or invisible solar spectrum to a point where it actually came to an end. What the wave-length of this point was we could not tell, for it lay entirely outside of what theory had till then pronounced possible.

Next, using the grating, we have at Allegheny determined the wave-lengths of most of the newly discovered solar heat region, by direct observation, and shown that it extended to the unanticipated length of 2.7 μ (*e*, Plate I) (*i. e.*, 27,000 on Angstrom's

scale).[4] I cite these facts, which have already been published, to bring us up to the point where the present researches begin.

The question now arises, "Does this ultimate observable wave-length of solar heat of $2\mu.7$, which our atmosphere transmits, correspond to the lowest which can be obtained from any terrestrial source, or are the wave-lengths emitted from our planet towards space, even greater, and conceivably such that our atmosphere is nearly athermanous to them?" To answer this it becomes necessary to do what I think has not been attempted before; to take a source of very low temperature, comparable to that of the soil, and not only to measure its extremely feeble invisible heat, but to draw this out into a spectrum by means of the prism or grating, and to determine the indices of refraction of its prominent parts, and by inference, their wave lengths. We have now been engaged on this research at Allegheny at intervals for two years, a time which will not appear extravagant to one acquainted with its extreme difficulties. Not to dwell on these in detail, I will mention only that the grating can not well be used on account of its overlapping spectra, if for no other reason, and that the most transparent glass, which we have found to be comparatively diathermanous to dark solar heat, turns out to be almost absolutely athermanous to the heat from a surface at the temperature of boiling water.

Glass being useless here, almost the only material of which we can form our prism is rock-salt, and we must have not only an entire train of lenses (both collimating and observing) of salt, as well as the prism, but the pieces must be of exceptional size, purity and perfection of figure, to contend with these special difficulties, and they must be maintained in condition, in spite of the incessant deterioration of this substance. Finally, as we wish to determine wave-lengths, these measures must be very accurate, and the prism be capable of giving fixed points of reference like the visible Fraunhofer lines. The best salt prisms I could get in Europe scarcely showed a single Fraunhofer line, and the best known European makers have assured me that no rock-salt prism ever did or could do more. I spent a long time in searching for good pieces of rock-salt, the best I have being due to the kindness of Prof. C. S. Hastings, and I am happy to say that the skill of our American opticians has produced what was pronounced impossible,—a prism of rock-salt which shows the Fraunhofer lines with the sharpness

[4] The other portions of this figure will be described later.

of one of flint glass. Such prisms have been made for us by Messrs. A. Clark & Sons of Cambridge, and Mr. J. A. Brashear of Pittsburgh. The one we are now using is made by the latter, and when freshly polished, gives a spectrum not only filled with hundreds of Fraunhofer lines, but which shows distinctly the nickel line between the D's, and is probably the finest one ever produced from this material. A more particular description of it is given later, and I wish to say that this task would have been almost impossible, were it not for our good fortune in having in the neighborhood, an optician of Mr. Brashear's skill.

Such measures on the collective heat of black bodies as those of Melloni and Tyndall have been made on large radiating surfaces, like those of the Leslie cube, but in order to form a spectrum, of this as of any other source, we must, of course, take only such a limited fraction of the side of the cube as is represented by a narrow spectroscope slit; so that both from its minute amount and feeble intensity (even if we can pass it through a prism, to form a spectrum), it is absolutely inappreciable, in anything like homogeneous portions, to the most delicate thermopile, and difficult of attack even by the bolometer.

We have employed as radiating surfaces, Leslie cubes covered with lampblack and filled with boiling water or aniline, the former giving a radiating surface of a temperature of 100° C., the latter one of 178° C. and also cubes filled with freezing mixtures, with the latter of which Mr. F. W. Very of this observatory conducted in the cold days of last March, one series of measures in which the radiator was the bolometer itself, at a temperature of —2°C. and the source radiated to, a vessel filled with a mixture of salt and snow at the temperature of —20° C., thus determining the distribution of energy in the spectrum of a surface below the freezing point of water. The Leslie cube used in these experiments was filled either with a freezing mixture or with water, kept gently boiling by a Bunsen burner underneath; or again, when measurements from a source at an exactly determinable higher temperature were desired, with aniline, which has a boiling point of about 178° C. A condensing apparatus connected with the cube, in the latter case prevented the escape of the aniline vapor. It was also found possible to keep the cube at any intermediate temperature within sufficiently narrow limits by properly adjusting the flame.

The apparatus is shown in Plate 2. Between the blackened side of the Leslie cube C and the spectrometer slit S, were inter-

posed a large pasteboard screen (*a*) and a flat copper vessel (*b*) filled with broken ice, both pierced with apertures slightly larger than the slit, to allow the passage of the rays, and the exposures were made by withdrawing a third hollow screen (*c*) made of copper and filled with ice, which cut off the radiation of the cube from the slit when it was in place.

The train for forming the spectrum upon the bolometer face consisted of two rock-salt lenses L, L and a rock-salt prism P. Each lens is 75 mm. in diameter and 350 mm. focus for visible rays. For the infra-red rays measured on, the focus is from one to two centimetres greater than this. The prism is made from an unusually perfect piece of rock-salt, and is 64 mm. on a side. With this train, composed entirely of rock-salt, and an ordinary eye-piece, the Fraunhofer lines are very distinctly visible in either sunlight or moonlight. The lenses, prism, slit and other parts of the train were mounted upon the large spectrometer (described in the Am. Journal of Science, Vol. XXV, 1883, and in the Mt. Whitney Report, Chapter XI).

To illustrate the use of the apparatus, we give below in detail the observations of March 20, 1885, for determining the form of the energy curve in the spectrum of a Leslie cube at 178° C. The temperature of the room was —7° C., so that the excess of the temperature of the cube over that of the room was 185° C.

The reading of the circle was made 0° 0′ 0″ when the spectrometer arms were in line, and the direct image of the slit fell on the bolometer. The prism was then placed on its table, the automatic minimum deviation apparatus connected, and the prism set to minimum deviation by a sodium flame held in front of the slit. The deviation of the ray falling upon the bolometer was then given directly by the circle reading to 10″.

The bolometer used was 2 mm. wide, and consequently subtended an angle of about 20′ in the spectrum. After adjusting the prism, the slit was opened to the same width. A secondary object of the experiment was the determination of the transmission of rock-salt in different parts of the spectrum, and for this purpose a plate of polished rock-salt, whose thickness was 9.1 mm., was interposed at the slit, after each deflection obtained in the ordinary manner, the plate being allowed to remain in each case till the bolometer had registered the heat due to radiations from the salt

SECTION B.

PHYSICS.

PAPERS READ.

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Next, using the grating, we have at Allegheny determined the wave-lengths of most of the newly discovered solar heat region, by direct observation, and shown that it extended to the extraordinary length of 2.7 μ (*c.* Plate I (*i.e.* 27,000 on Angstrom's

scale).[4] I cite these facts, which have already been published, to bring us up to the point where the present researches begin.

The question now arises, "Does this ultimate observable wave-length of solar heat of $2\mu.7$, which our atmosphere transmits, correspond to the lowest which can be obtained from any terrestrial source, or are the wave-lengths emitted from our planet towards space, even greater, and conceivably such that our atmosphere is nearly athermanous to them?" To answer this it becomes necessary to do what I think has not been attempted before; to take a source of very low temperature, comparable to that of the soil, and not only to measure its extremely feeble invisible heat, but to draw this out into a spectrum by means of the prism or grating, and to determine the indices of refraction of its prominent parts, and by inference, their wave-lengths. We have now been engaged on this research at Allegheny at intervals for two years, a time which will not appear extravagant to one acquainted with its extreme difficulties. Not to dwell on these in detail, I will mention only that the grating can not well be used on account of its overlapping spectra, if for no other reason, and that the most transparent glass, which we have found to be comparatively diathermanous to dark solar heat, turns out to be almost absolutely athermanous to the heat from a surface at the temperature of boiling water.

Glass being useless here, almost the only material of which we can form our prism is rock-salt, and we must have not only an entire train of lenses (both collimating and observing) of salt, as well as the prism, but the pieces must be of exceptional size, purity and perfection of figure, to contend with these special difficulties, and they must be maintained in condition, in spite of the incessant deterioration of this substance. Finally, as we wish to determine wave-lengths, these measures must be very accurate, and the prism be capable of giving fixed points of reference like the visible Fraunhofer lines. The best salt prisms I could get in Europe scarcely showed a single Fraunhofer line, and the best known European makers have assured me that no rock-salt prism ever did or could do more. I spent a long time in searching for good pieces of rock-salt, the best I have being due to the kindness of Prof. C. S. Hastings, and I am happy to say that the skill of our American opticians has produced what was pronounced impossible,—a prism of rock-salt which shows the Fraunhofer lines with the sharpness

[4] The other portions of this figure will be described later.

of one of flint glass. Such prisms have been made for us by Messrs. A. Clark & Sons of Cambridge, and Mr. J. A. Brashear of Pittsburgh. The one we are now using is made by the latter, and when freshly polished, gives a spectrum not only filled with hundreds of Fraunhofer lines, but which shows distinctly the nickel line between the D's, and is probably the finest one ever produced from this material. A more particular description of it is given later, and I wish to say that this task would have been almost impossible, were it not for our good fortune in having in the neighborhood, an optician of Mr. Brashear's skill.

Such measures on the collective heat of black bodies as those of Melloni and Tyndall have been made on large radiating surfaces, like those of the Leslie cube, but in order to form a spectrum, of this as of any other source, we must, of course, take only such a limited fraction of the side of the cube as is represented by a narrow spectroscope slit; so that both from its minute amount and feeble intensity (even if we can pass it through a prism, to form a spectrum), it is absolutely inappreciable, in anything like homogeneous portions, to the most delicate thermopile, and difficult of attack even by the bolometer.

We have employed as radiating surfaces, Leslie cubes covered with lampblack and filled with boiling water or aniline, the former giving a radiating surface of a temperature of 100° C., the latter one of 178° C. and also cubes filled with freezing mixtures, with the latter of which Mr. F. W. Very of this observatory conducted in the cold days of last March, one series of measures in which the radiator was the bolometer itself, at a temperature of —2°C. and the source radiated to, a vessel filled with a mixture of salt and snow at the temperature of —20° C., thus determining the distribution of energy in the spectrum of a surface below the freezing point of water. The Leslie cube used in these experiments was filled either with a freezing mixture or with water, kept gently boiling by a Bunsen burner underneath; or again, when measurements from a source at an exactly determinable higher temperature were desired, with aniline, which has a boiling point of about 178° C. A condensing apparatus connected with the cube, in the latter case prevented the escape of the aniline vapor. It was also found possible to keep the cube at any intermediate temperature within sufficiently narrow limits by properly adjusting the flame.

The apparatus is shown in Plate 2. Between the blackened side of the Leslie cube C and the spectrometer slit S, were inter-

posed a large pasteboard screen (*a*) and a flat copper vessel (*b*) filled with broken ice, both pierced with apertures slightly larger than the slit, to allow the passage of the rays, and the exposures were made by withdrawing a third hollow screen (*c*) made of copper and filled with ice, which cut off the radiation of the cube from the slit when it was in place.

The train for forming the spectrum upon the bolometer face consisted of two rock-salt lenses L, L and a rock-salt prism P. Each lens is 75 mm. in diameter and 350 mm. focus for visible rays. For the infra-red rays measured on, the focus is from one to two centimetres greater than this. The prism is made from an unusually perfect piece of rock-salt, and is 64 mm. on a side. With this train, composed entirely of rock-salt, and an ordinary eye-piece, the Fraunhofer lines are very distinctly visible in either sunlight or moonlight. The lenses, prism, slit and other parts of the train were mounted upon the large spectrometer (described in the Am. Journal of Science, Vol. XXV, 1883, and in the Mt. Whitney Report, Chapter XI).

To illustrate the use of the apparatus, we give below in detail the observations of March 20, 1885, for determining the form of the energy curve in the spectrum of a Leslie cube at 178° C. The temperature of the room was —7° C., so that the excess of the temperature of the cube over that of the room was 185° C.

The reading of the circle was made 0° 0′ 0″ when the spectrometer arms were in line, and the direct image of the slit fell on the bolometer. The prism was then placed on its table, the automatic minimum deviation apparatus connected, and the prism set to minimum deviation by a sodium flame held in front of the slit. The deviation of the ray falling upon the bolometer was then given directly by the circle reading to 10″.

The bolometer used was 2 mm. wide, and consequently subtended an angle of about 20′ in the spectrum. After adjusting the prism, the slit was opened to the same width. A secondary object of the experiment was the determination of the transmission of rock-salt in different parts of the spectrum, and for this purpose a plate of polished rock-salt, whose thickness was 9.1 mm., was interposed at the slit, after each deflection obtained in the ordinary manner, the plate being allowed to remain in each case till the bolometer had registered the heat due to radiations from the salt

itself, when the screen was withdrawn and the radiations from the Leslie cube allowed to pass through it.

The results are given below in the form of a table.

Deviation.	Deflection.	Deflection with rock-salt plate interposed.	Transmission of plate.
40° 30′	12		
40 00	72		
39 30	214		
39 00	364		
38 30	420	360	.857
38 00	365		
37 30	269	251	.933
37 00	196		
36 30	137	122	.891
36 00	96		
35 30	62	63	1.02
35 00	48		
34 30	29	27	.931
34 00	26.5		
33 30	18	14	.778
33 00	10.5		

The "transmission" of the plate of rock-salt (here uncorrected for heat lost by reflection at the anterior surface) has been shown by repeated subsequent experiments to slightly but sensibly diminish for extreme heat rays in the Leslie cube spectrum; but to remain so nearly constant through the range of these experiments, as to show that the present approximate values need no correction on this account.

The following series was then taken for fixing more accurately the position of the maximum:

Deviation.	Deflection.
39° 00′	375
38 50	406
38 40	430
38 30	428
38 20	414
38 10	401
38 00	371

From curves representing these observations, it was concluded that the maximum was at 38° 35′. It will be shown further on, how an attempt may be made to estimate the wave-lengths in these regions.

Measurements were also made with surfaces of copper heated to much higher temperatures, and with the cube at different lower temperatures, for the purpose of determining whether the position of the maximum of the energy curve varies with the temperature, and if so to determine if possible the relation. Experiments of this kind have been made by Mr. W. W. Jacques,[5] who found that "the distribution of heat in the spectrum of a solid or liquid source of radiation is nearly independent of the temperature of the source." It was evident from the care with which Mr. Jacques' experiments were conducted, that the shifting of the maximum must be slight and difficult of quantitative determination, but with the pure spectrum and delicate heat measuring apparatus at our command, it was thought possible that this might be effected. Accordingly, measurements similar to those just described were made with a radiating surface of lamp-blacked copper at the approximate temperatures of 815° C., 525° C. and 330° C., and with the Leslie cube at temperatures of 178° C., 100° C., 40° C. and —20° C., the excess over the temperature of the room being in the latter cases respectively 185° C., 88° C., 46° C. and —18° C. In the last instance, the cube was colder than the bolometer strips, and the deflections obtained were negative; though small, they were distinctively measurable, the greatest being —12 divisions of the galvanometer scale.[6] We have in Plate 3 the curves representing the radiation from these sources, in which the abscissæ are proportional to the indices of refraction in the rock-salt prism and the ordinates approximately so to the deflections of the galvanometer due to the heat at the corresponding points. The total radiation in each case is then approximately proportional to the area of each curve.

[5] Distribution of heat in the spectra of various sources of radiation, by William W. Jacques, Ph. D., Proceedings of American Academy.

[6] The position of the maximum in the ice curve is indicated, but the curve itself is, on this scale of ordinates, sensibly coincident with the straight line. (See Plate 1.)

Date of observation.	Approximate temperature of source.	Approximate temperture of excess.	Deviation of maximum ordinate in heat curve.
1885.			
October 7,	815° C.	803° C.	39'.06'
" 8,	525	505	39 03
" 7,	330	318	39 01
" 8,	330	310	39 00
September 26,	300	275	38 42
March 29,	178	185	38 35
August 19,	179	153	38 35
March 20,	119	126	38 25
October 7,	100	88	38 22
October 3,	99	79	38 27
March 21,	40	46	38 00
" 24,	—03	—18	37 40'

It is to be observed of each of the curves in Plate 3 that though nearly all the *area* is seen, yet that owing to the extension of the heat curve toward the right, the length shown is limited here by the size of the plate, whereas the extremity measured in each curve (except of course the solar one) does, in fact, correspond to an index of less than 1.45. We give above a table showing the dates of observation, the approximate temperatures of excess and the approximate deviations of the ordinate corresponding to the point of maximum heat in the (rock-salt) prismatic spectrum. We should observe that the higher temperatures are here only determined with an approximation sufficient to make it certain that there is a progression in the position of the maximum heat-ordinate corresponding to the temperature, as the latter rises. These results, both in the table and as represented in the plates, are given as preliminary, not as final, for we hope soon to be able to offer other and more exact ones deduced from the heat spectra of bodies at all temperatures between that of melting platinum and melting ice. We are entitled, however, even at present, to draw the following conclusions, which are of special interest in connection with the spectra of dark bodies, of which almost nothing has been hitherto known.

* The position of the maximum in this latter case depends upon a single observation of some delicacy and is liable to subsequent correction.

(1) The heat represented by the areas of these curves is *almost altogether of a character not observed in that of the sun*, these wave-lengths, in general, not being transmissible by glass, which is comparatively permeable to the lowest solar heat waves that penetrate our atmosphere.[8] To show this more clearly we have drawn the solar spectrum given by the rock-salt prism in its true position though not in its true amount relatively to that of the heat curves cited. The maximum of the latter lies in every case, it will be seen, far below the very lowest part of the solar invisible heat.

(2) In spite of the compression of the infra-red by the prism, these heat curves extend almost indefinitely in the direction of the smaller indices, so far that we can, in fact, represent only a part of this extent in our plate. The measures already cited in case of the curve for the Leslie cube at 178°, for instance, show very measurable heat at a deviation of 33°, which corresponds to an index of refraction of 1.4511, while the smallest index given in the plate is 1.49.

(3) An increase of temperature increases every ordinate, but not in like proportions, ordinates corresponding to the heat in the more refrangible parts, always growing more rapidly than those for less refrangible heat.

(4) As a necessary consequence of this, follows the (independently observed) fact of the progressive movement of the maximum ordinate, toward the more refrangible end as the temperature rises.

(5) These prismatic curves are not symmetrical, the greater portion of the area in every case lying below the maximum, *i. e.*, toward the greater wave-length, and the descent being always most abrupt on the more refrangible side.

As the heat spectra from surfaces at the temperature of boiling water or melting ice are those to which the chief interest attaches, in connection with the temperature of the soil, and as these are not well shown on the same scale of ordinates with that of the red-hot copper, we give an independent representation of these two in Plate 1, but upon the wave-length, not the prismatic scale. Their maxima of heat fall at points in the normal spectrum

[8] The distinctive character of these radiations is also well shown by the fact that we have found that a thick film of lampblack, which is nearly as impervious to the dark solar heat as to light, transmits more than 50 per cent of some of the rays in question.

which (as we explain later) are only approximately determinate on *this* scale, but which are probably at least as low as the points (*f*) corresponding to the boiling water maximum, and (*g*) corresponding to the position of the maximum ordinate in the spectrum of ice at the melting point, or lower. No attempt is made in this plate to represent the relative *amounts* of heat in the solar and Leslie cube curves, but only their positions on the wave-length scale; and here also it will be understood that the latter curves really extend far further to the right than the limits of the plate admit of showing them.

These observations, then, show a real though slight progresssion of the point of maximum heat toward the shorter wave-lengths as the temperature rises. The position of the maximum ordinate of the lower curves is of course more difficult to determine, on account of their flatness.

The whole heat spectrum from most of these sources, it is interesting to note, passes through the prism at angles which the theories of our text books have heretofore pronounced impossible. The existence of these radiations, and the relative amounts of heat for each deviation are certain, for these deviations are determined by the spectro-bolometer, in most cases with a probable error of less than a minute of arc; but when we pass to the next stage of our work, the determination of the corresponding wave-lengths, we cannot speak with such confidence. We have calculated the wave-lengths for some of the observations by means of Wüllner's new formula[9] (which is founded on Helmholtz's theory, but which he has tested by our own observations with the glass prism) and found them to agree with similar ones obtained directly from the curve representing the relation between n and λ for rock-salt, which is shown in Plate 4, by measurements on points whose wave-lengths were known from these prior observations up to about 20,000 of Angstrom's scale. Beyond this point we have continued the curve both by computation and by graphical extrapolation. We do not disguise from ourselves the danger of all extrapolations, but here we have, up to the time of writing nothing else to depend on, and must use them. Our extrapolations rest, however, it will be seen, on a wholly different basis from the ones depending on formulæ derived from the visible spectrum alone, since our curve has been

[9] Wiedemann's Annalen Band, 33, p. 307.

already followed by direct observations until it is almost coincident with a straight line. Up to this point then (within the limits of error already elsewhere given) there is no doubt, and unless there is some utter change in the character of the curve, such as we have no reason to anticipate, a tangent from the last part will not differ very greatly from the immediate course of the curve itself, and will at any rate meet the axis of abscissæ sooner than the curve can. If we assume then the prolongation of the curve to agree with this tangent, we evidently assume a minimum value for all the wave-lengths measured by it, and that is what we have done.

We are not prepared yet to speak of these wave-length values as exactly determinate, and they are here given as first approximations. They are indeed sufficiently startling, to make us inclined to proceed with caution; but, speaking with the reserves indicated by the conditions referred to, I may say that we have every reason to believe that the minimum wave-length assignable to the maximum ordinate of the heat curve, in the spectrum of a source whose temperature varies from 100° to 0° Centigrade, is a little less than 5μ and a little over 6μ and that these may be indefinitely greater. This refers, it will be remarked, only to the position of the maximum ordinate, while the extreme portions of the curve measured on (corresponding to an index of 1.45) have probably at least three times this wave-length. I shall be better understood, perhaps, if I say that some of the heat radiated by the soil has probably a wave-length of *over* 150,000 of Angstrom's scale, or about twenty times the wave-length of the lowest visible line in the solar spectrum, as known to Fraunhofer.

These investigations are still going forward, and I hope soon to give more exact values. But I have presented the present ones, though imperfect, because they give us at least some knowledge of a region of which we are at present quite ignorant, and because they are thus I think of some interest both to the physicist and to the astronomer. To the physicist, as showing that the wave-lengths which Newton measured to the $\frac{1}{10,000}$ of an inch are so far from being the limits of nature's scale, that the existence of measurable wave-lengths of something greater than $\frac{1}{2,000}$ of an inch is rendered at least highly probable. To the astronomer, because we find that *the heat radiated from the soil is of an almost totally different quality from that which is received from the sun* so that

the important processes by which the high surface temperature of the planet are maintained, can now be investigated with, we may hope, fruitful results in connection with the researches here described.

I should not close this preliminary account without stating that I have in these observations been throughout and at every stage, indebted to Messrs. F. W. Very and J. E. Keeler of this Observatory, for a collaboration without which it could not have appeared in its present form.

Addendum.

Reduction of observations made with the rock-salt prism to a standard refracting angle; with a table of refractive indices of rock-salt.

The surfaces of the rock-salt prism and lenses undergo a deterioration when exposed to the air, which is more or less rapid, according to the greater or smaller relative humidity of the atmosphere at the time. In ordinary dry weather they may be used several times before they become spoiled, while in damp or rainy weather three or four seconds is a sufficiently long time to cover them with condensed moisture, and work under these circumstances is of course impossible. After the surfaces have in this way become unfit for use they are repolished, and the refracting angle of the prism is thereby unavoidably altered. The change is usually small, generally not exceeding 1′, so that for most of our heat measures it may be neglected altogether. The changes have, however, tended on the whole, to reduce the refracting angle, so that it is now about 4′ smaller than when the prism was first used.

To make all observations strictly comparable, they are reduced to one value of the refracting angle, for which the deviations of the Fraunhofer lines, and the wave-lengths corresponding to given deviations in the infra-red, have been determined with the greatest possible accuracy. This standard value of the refracting angle is 59° 57′ 54″. A series of observations for fixing the positions of the Fraunhofer lines was made by Mr. J. E. Keeler of this Observatory on Sept. 14, 1885. One arm of the spectrometer, which was firmly clamped, carried a glass collimating lens of 25 feet focus, and the other an achromatic observing telescope of nearly four

feet focus, with a micrometer eyepiece. The double deviations of the C, D_1, b_1, and F lines were observed, and also the differences of deviation between these and the other lines whose positions were determined. For observing the M and N lines a Soret fluorescent eyepiece was used, and in the infra-red, a bolometer, having a single strip $\frac{1}{10}$ millimetre in width. In the two last cases the prism was automatically kept in the position for minimum deviation. The spectrometer circle reads by two opposite verniers to 10″, but on account of the construction of the instrument (for whose principal purpose arms whose length is inconsistent with absolute rigidity had to be used), care is necessary to measure an angle with this degree of precision, as the arms are liable to spring slightly on the application of lateral pressure. The deviations given in our table were obtained by Mr. Keeler by setting on the line with the micrometer eyepiece, after the telescope had been directed upon it and freed from strain by a light tap; and applying the micrometer correction to the circle reading. It was found by a careful comparison of the solar spectrum given by the rock-salt prism with that by a fine prism of flint glass, that, in spite of the greater dispersion of the latter, no lines could be seen in its spectrum which the rock-salt prism would not also show. The probable error of one setting of the micrometer was less than 1″. From the agreement of the different measurements made in this way, it is believed that the deviations throughout the visible spectrum are correct to within 5″. Those in the ultra-violet and infra-red cannot of course pretend to this degree of accuracy. The positions of ρ ς τ (invisible) given by two independent series with the bolometer differed by 30″; those of φ (invisible) by 1′, those of ψ (invisible) by 30″ and those of Ω (invisible) agreed exactly.

We have thus obtained incidentally the data for constructing a table of refractive indices of rock-salt throughout the entire range of the solar spectrum, with an accuracy which we believe to be greater than has heretofore been attained, and which we deem of sufficient interest to give in full below, for the convenience of others having occasion to work with this material, and for testing theories of dispersion.

REFRACTING ANGLE OF PRISM = 59° 57′ 54″.

Line.	Wave-length.	Deviation.	Δ	Refractive Index.
M	0μ.3727	43° 50′ 57″	1.21	1.57486
L	0.3820	43 35 27	1.20	1.57207
H_2	0.3933	43 19 32	1.19	1.56920
H_1	0.3968	43 14 44	1.19	1.56833
G	0.4303	42 36 7	1.16	1.56133
F	0.4861	41 51 47	1.13	1.55323
b_4	0.5167	41 33 43	1.12	1.54991
b_1	0.5183	41 32 52	1.12	1.54975
D_1	0.5889	41 2 41	1.10	1.54418
D_2	0.5895	41 2 29	1.10	1.54414
C	0.6562	40 42 56	1.09	1.54051
B	0.6867	40 35 49	1.09	1.53919
A	0.7601	40 22 25	1.08	1.53670
ρ ς τ	0.94	40 1 26	1.07	1.5328
φ	1.13	39 49 11	1.06	1.5305
ψ	1.38	39 39 56	1.05	1.5287
Ω	1.82	39 29 21	1.05	1.5268

Temp.= 24° C. Barometer, 733.1 mm.

The wave-lengths of the M and L lines are from Cornu, those of the lines between H and A inclusive, from Angstrom, and those of the infra-red bands from the Allegheny observations. The column headed Δ was prepared at the suggestion of Mr. Keeler, and is for the purpose of facilitating the reduction of observations made with a different prism angle from that for which the table is computed and for which our wave-length curves are drawn. If we differentiate the ordinary formula for a prism,

$$n = \frac{\sin. \frac{1}{2}(A+d)}{\sin \frac{1}{2} A}$$

with respect to A, which we now regard as a variable, we have

$$\frac{dd}{dA} = \frac{n \cos \frac{1}{2} A}{\cos \frac{1}{2}(A+d)} - 1 = \Delta$$

or $$dd = \Delta \, d\, A$$

The values of Δ for the different lines of the spectrum are readily

computed from the table of deviations and refractive indices. To find then, the deviation of a line after any repolishing of the prism, we have merely to multiply the change of the angle by the approximate value of Δ taken from the table, and we obtain the change in the deviation of the line, and hence also the deviation required. Thus, if the new angle is found on measurement to be 59° 57′ 44″, $dA = -10''$, and the deviation of the F line (say) will have been changed by $-10'' \times 1.13 = -11.3''$. That is, the deviation of the F line is now 41° 51′ 36″. The reduction from the new to the standard angle is of course the reverse of this, and that the use of the table saves much labor in redetermining the constants of the prism will be understood when it is added that ours has been entirely refigured and repolished by the maker as many as ten times during the present year.

and restored at will by alternately bringing the solution into the field and withdrawing it.

(*d*) With hydrochloric acid the magnet causes slight increase of speed of solution and increase in the amount of heat produced. No change in the nature of the reaction was observed. The percentage of ferric chloride in the solution at the close of the reaction was not found to be larger where the experiment took place in the magnetic field than under other circumstances.

(*e*) With hydrochloric acid in the presence of an excess of potassium chlorate, under which circumstances all the iron was rapidly converted into ferric chloride, the speed of reaction and amount of heat produced were greater *without* than within the magnetic field.

(*f*) With sulphuric acid the magnet caused a slight increase of speed and decrease in the amount of heat produced by the reaction.

(*g*) With nitric acid acting upon copper no magnetic effect could be detected.

PSYCHROMETRY. By Prof. WM. FERREL, Signal Service Office, Washington, D. C.

[ABSTRACT.]

THIS paper treats briefly of the great imperfections in the principles and methods of psychrometry as still most generally used and of the advisability of adopting the whirled or sling psychrometer, as recently determined upon by the Signal Service. It also gives some account of the steps taken by the Signal Service in obtaining a new constant for the pyschrometric formula adapted to the sling pyschrometer from experiments now being made for the purpose in Colorado, with a sling pyschrometer and the Regnault dew-point apparatus, and of the results likely to be obtained from them, as already indicated from a partial discussion of the data. The whole matter will be finally published by the Signal Service office.

[1] Preliminary Note on the Action of Acids upon Iron in the Magnetic Field. Proceedings A. A. A. S., 1884.

APPARENT RESISTANCE OF A BODY OF AIR TO A CHANGE OF FORM UNDER SUDDEN COMPRESSION. By Comdr. THEO. F. JEWELL, U. S. N., Torpedo Station, Newport, R. I.

[ABSTRACT.]

Discs of compressed gun-cotton, on which are stamped certain letters and figures, when exploded on wrought iron plates, leave markings on the plates similar to those on the discs. The markings are depressions in both cases, but are inverted on the iron plate. It is suggested that the air enclosed in the letters and figures, under the sudden and enormous pressure to which it is subjected, acts like a hard body and is thus driven into the iron.

[A disc of gun-cotton and an iron plate on which a similar disc had been exploded were exhibited at the meeting.]

TELEMETRIC AID TO METEOROLOGICAL RECORDS. By HENRY E. ALVORD, C. E., Houghton Farm, Mountainville, N. Y.

[ABSTRACT.]

A REPORT of progress in endeavoring to secure at Houghton Farm, mechanical devices for automatic and continuous records of meteorological phenomena. The experience with special mercurial thermometers, and thermo-couples, in taking soil and atmospheric temperatures, is described in Houghton Farm pamphlets, Agricultural Physics, Series I, Nos. 3 & 4, 1883: Penhallow. This paper describes a recent trial of the system of Telemetry in connection with temperatures.

This term, Telemetry, has been applied to electrical apparatus, by which variable physical forces, such as temperature and pressure, are indicated and recorded at any distant point. The system consists of two instruments, the transmitter, which indicates the variable force at the place where it exists, and the receiver or counterpart instrument at the place where the variations are desired to be known, to which the recorder is attached. These two instruments are maintained in perfect unison, automatically, by the skilful application of electricity, upon the open circuit prin-

PLATE III.

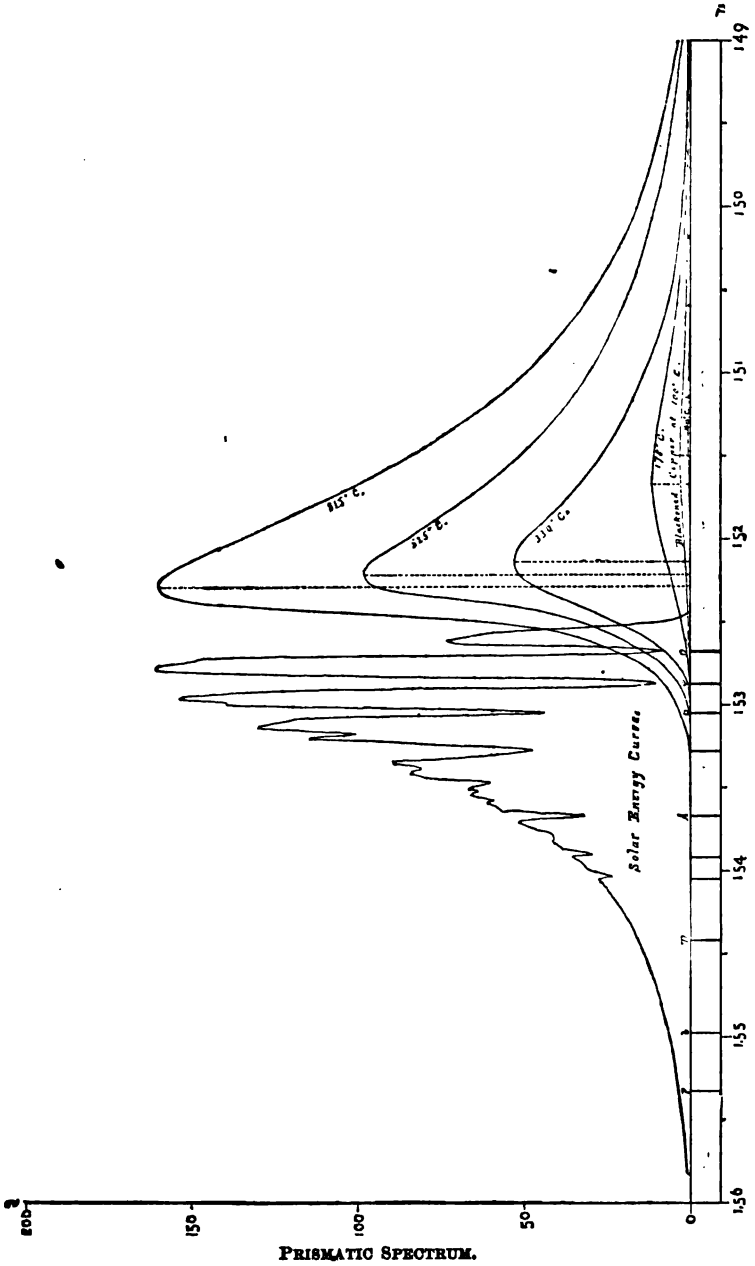
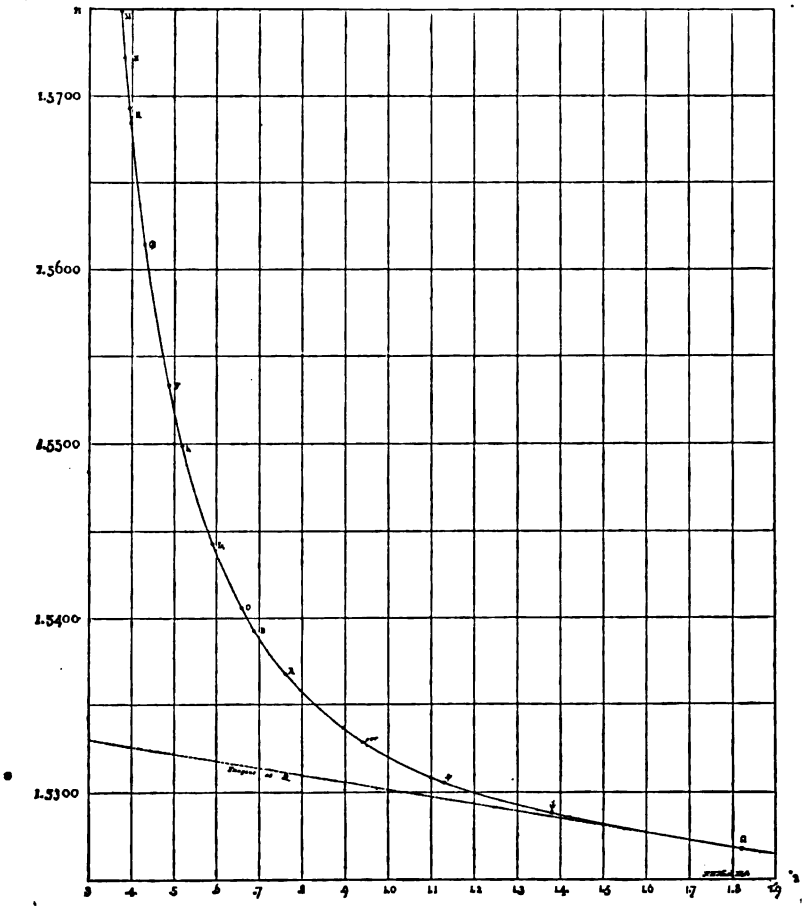


PLATE IV.



SHOWING $n = f(\lambda)$ FOR ROCK SALT.

A PRACTICAL METHOD OF WORKING ROCK SALT SURFACES FOR OPTICAL PURPOSES.

By JNO. A. BRASHEAR, Pittsburg, Pa.

Two years or more since, Prof. Langley asked me to undertake the work of polishing the rock salt trains so frequently called into use in his well-known researches in obscure heat rays. These surfaces, under the very best conditions, are ephemeral in their character, owing to the deliquescent nature of the material, and in order to get the best results from them, frequent repolishing and refiguring are absolutely necessary. I have been informed that the French opticians polish all rock salt surfaces upon broadcloth; and, indeed, almost all surfaces I have tested show them to have been finished upon some yielding material, as the edges are almost always rounded or as I would call it, over corrected. This is fatal to good results in any optical surface. Mr. George Clark of Alvan Clark & Sons polished a prism for Prof. Langley which turned out to be beautiful in polish and in figure. His method was to use a pitch polisher, with "diamantine" (a fine variety of Vienna lime) as the polishing material. A strong brine was used instead of water in the ordinary way. Mr. Clark informed me that the one great difficulty he met with was to wipe the prism surfaces, *after the polishing was completed*, he using the arm or palm of the hand, in preference to anything else. On a few occasions I have succeeded in this way, but where success may be had once, failure may result twenty times, for if any moisture is left on the surface of the prism or lens, even for a moment of time, it is ruined.

Happily I have no trouble in this respect now, and as my method is easily carried out by any physicist who desires to work with rock salt surfaces, it gives me pleasure to explain it. For polishing a prism I make an ordinary pitch bed of about two and one-half or three times the area of the surface of the prism to be polished. While the pitch is still warm I press upon it any approximately flat surface, such as a piece of ordinary plate glass. The pitch bed is then cooled by a stream of water, and conical holes are then drilled in the pitch with an ordinary counter sink bit, say ¼ in. diameter, and at intervals of half an inch over the entire surface. This is done to relieve the atmospheric pressure in the final work. The upper surface of the pitch is now very slightly warmed and a true plane surface (usually a glass one, prepared by

grinding and polishing *three* surfaces in the ordinary way, previously wetted), is pressed upon it until the pitch surface becomes an approximately true plane itself. Fortunately, moderately hard pitch retains its figure quite persistently through short periods and small changes of temperature, and it always pays to spend a little time in the preparation of the pitch bed.

The polisher being now ready, a very small quantity of rouge and water is taken upon a fine sponge and equally distributed over its surface. The previously ground and fined salt surface (this work is done the same as in glass working) is now placed upon the polisher and motion *instantly* set up in diametral strokes. I usually walk around the polisher while working a surface. It is well to note that motion *must be constant*, for a moment's rest is fatal to good results, for the reason that the surface is quickly eaten away, and irregularly so, owing to the holes that are in the pitch bed. Now comes the most important part of this method. After a few minutes' work the moisture will begin to evaporate quite rapidly. No new application of water is to be made, but a careful watch must be kept upon the pitch bed and as the last vestige of moisture disappears the prism is to be slipped off the polisher in a perfectly horizontal direction, and if the work has been well done, a clean, bright and *dry* surface is the result. The surface is now tested by the well-known method of interference from a perfect glass test plate.

If an error of concavity presents itself the process of polishing is gone over again, using *short* diametral strokes. If the error is one of convexity, the polishing strokes are to be made along the chords, extending over the edge of the polisher. The one essential feature of this method is the fact that the surface is *wiped dry* in the final strokes, thus getting rid of the one great difficulty of pitch polishing, a method undoubtedly far superior to that of polishing on broadcloth. If in the final strokes the surface is not quite cleaned I usually breathe upon the pitch bed, and thus by condensation place enough moisture upon it to give a few more strokes, finishing just the same as before. In ten minutes I have polished prisms of rock salt in this manner that have not only shown the D line double, but Prof. Langley has informed me that his Assistant, Mr. Keeler (J. E.) has seen the nickel line clearly between the D lines. This speaks for the superiority of the surfaces over those polished on broadcloth.

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as they can be easily held, but as it is difficult to hold lenses or planes in this way, without injuring the surfaces, I usually support them in a block of soft wood, turned so as to touch only at their edges, and work the polisher over them. Though it takes considerable practice to succeed at first, the results are so good, that it well repays the few hours' work it requires to master the *few* difficulties it presents.

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AN element constructed of carbon in saturated solution of bichromate of potash and sulphuric acid and zinc in saturated solution of ammonium chloride has E. M. F. of 2.1 volts. Internal R according to size but generally less than half an ohm. Its constancy recommends it as it yields a strong current until it is exhausted and gives no fumes. If nitric acid be used instead of sulphuric acid the E. M. F. is 2.3 volts, which is higher than that of any element with ordinary available material that I know of.

ON SURFACE TRANSMISSION OF ELECTRICAL DISCHARGES. By Prof. H. S. CARHART, Northwestern University, Evanston, Ill.

[ABSTRACT.]

THE Report of the Commissioner of Patents for 1859 contains an article by Professor Joseph Henry on "Atmospheric Electricity" in which the following passage occurs:—"If the discharge be not very large in proportion to the size of the conductor, it will principally be transmitted at the surface." One experiment is described, which was thought to demonstrate the truth of the statement. The present paper details the method and results of an experimental inquiry into the theory of surface transmission. Two glass tubes, about one metre each in length, were covered with tin-foil which constituted one branch of a divided circuit, the

other passing through the inside of the tubes. Between the tubes were placed two similar magnetizing spirals, one in each branch of the divided circuit. The two branches were adjusted to equal resistances. A Leyden jar was discharged through the compound circuit and the ratio of the charges conveyed by the two branches was measured by the magnetic moment imparted to two small steel rods placed in the spirals. The magnetization of A in the inner circuit was always apparently greater than that of B in the outer, after a single discharge. After about ten discharges the two showed nearly equal magnetic moments and both had reached a maximum. Some unexplained facts led to an exchange of the two magnets in the coils, keeping them turned so that their polarity would not be reversed. A single discharge of the Leyden jar then served to increase B's magnetization by 50 or 60 per cent and to diminish A's by half as much. Subsequent discharges increased the magnetism of both. An explanation was sought by removing gradually the exterior of both magnets by nitric acid, weighing after each immersion, and determining magnetic moments. The result was expressed graphically, showing that A's magnetic moment decreased from the first, while B's first increased to a maximum and then decreased. Thus B has a thin external shell of opposite polarity to the interior. When the magnets are exchanged in the spirals, this thin shell is magnetized in the same sense as the interior, while A suffers reversal of polarity on its exterior. Thus the magnetic moment of B increases and of A decreases. An explanation of this reversal was sought in the theory of the oscillatory discharge. This theory, first demonstrated mathematically by Sir Wm. Thomson, indicates that the period of the oscillation is lengthened by an increase of the capacity of the principal conductor. It is also lengthened by increasing the capacity of the discharger. Now the longer the period of the oscillation the greater the magnetic impulse produced by the discharge. This explains the reversal in B, since the capacity of its branch was much greater than that of the other. Experiments were made with conductors of different capacities; and the result, shown graphically, confirmed the indications of theory. The conclusion is that while B always shows a greater intensity of magnetization than A, the difference is probably due to difference in the periods of oscillation rather than to an unequal division of the discharge between the two branches.

THE RELATION OF VANISHING AND PERMANENT MAGNETISM. By Prof. H. W. EATON, Louisville, Ky.

[ABSTRACT.]

JAMIN found the following laws:—

1. The amount of the vanishing magnetism produced by a current is independent of the amount of permanent magnetism already present.

2. The decrease of the permanent magnetism of a bar by a current of the strength—i is independent of the amount of magnetism already present, and is double the permanent magnetism which the current $+ i$ will produce in the neutral bar.

Wiedemann and Chowolson obtained conflicting results.

Nine series of determinations with magnetizing currents of different strengths show that Jamin's first law holds good only when the bar is nearly saturated with magnetism. Wiedemann's results show that his bars were not thus saturated and this accounts for the different results obtained.

Sixteen series of tests show that Jamin's second law is approximately true when the demagnetizing current is one hundred or more on the scale used, but for weaker currents the law does not hold good.

NTROPY. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

THE LIFE OF THE UNIVERSE. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

A NEW HARMONOGRAPH. By Prof. CHAS. H. CHANDLER, Ripon, Wis.

NOTE ON ELECTROMETERS AND ATMOSPHERIC ELECTRICITY. By Prof. T. C. MENDENHALL, U. S. Signal Service Office, Washington, D. C.

ELECTROLYSIS OF SALTS OF THE ALKALIES AND ALKALINE EARTHS. By A. J. ROGERS, Milwaukee, Wis.

EXHIBITION OF A COMBINED SPECTROPHOTOMETER AND OPHTHALMOSPECTROSCOPE. By Prof. C. K. WEAD, Univ. of Michigan, Ann Arbor, Mich.

WEATHER CHANGES OF LONG PERIOD. By Dr. H. HELM CLAYTON, Ann Arbor, Mich.

THE DIRECT OPTICAL PROJECTION OF ELECTRO-DYNAMIC "LINES OF FORCE." By Dr. J. W. MOORE, Easton, Penn.

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A BERNSTEIN electric lamp of carbonized silk fibre having a resistance while hot of 3 ohms and requiring 30 volts gives 250 to 300 candle power, is steady, comparable with the lime light, and for efficiency is about the same as a good arc light being about one watt per candle.

ON A NEW GALVANIC ELEMENT. By Prof. A. E. DOLBEAR, Tufts College, College Hill, Mass.

[ABSTRACT.]

AN element constructed of carbon in saturated solution of bichromate of potash and sulphuric acid and zinc in saturated solution of ammonium chloride has E. M. F. of 2.1 volts. Internal R according to size but generally less than half an ohm. Its constancy recommends it as it yields a strong current until it is exhausted and gives no fumes. If nitric acid be used instead of sulphuric acid the E. M. F. is 2.3 volts, which is higher than that of any element with ordinary available material that I know of.

ON SURFACE TRANSMISSION OF ELECTRICAL DISCHARGES. By Prof. H. S. CARHART, Northwestern University, Evanston, Ill.

[ABSTRACT.]

THE Report of the Commissioner of Patents for 1859 contains an article by Professor Joseph Henry on "Atmospheric Electricity" in which the following passage occurs:—"If the discharge be not very large in proportion to the size of the conductor, it will principally be transmitted at the surface." One experiment is described, which was thought to demonstrate the truth of the statement. The present paper details the method and results of an experimental inquiry into the theory of surface transmission. Two glass tubes, about one metre each in length, were covered with tin-foil which constituted one branch of a divided circuit, the

other passing through the inside of the tubes. Between the tubes were placed two similar magnetizing spirals, one in each branch of the divided circuit. The two branches were adjusted to equal resistances. A Leyden jar was discharged through the compound circuit and the ratio of the charges conveyed by the two branches was measured by the magnetic moment imparted to two small steel rods placed in the spirals. The magnetization of A in the inner circuit was always apparently greater than that of B in the outer, after a single discharge. After about ten discharges the two showed nearly equal magnetic moments and both had reached a maximum. Some unexplained facts led to an exchange of the two magnets in the coils, keeping them turned so that their polarity would not be reversed. A single discharge of the Leyden jar then served to increase B's magnetization by 50 or 60 per cent and to diminish A's by half as much. Subsequent discharges increased the magnetism of both. An explanation was sought by removing gradually the exterior of both magnets by nitric acid, weighing after each immersion, and determining magnetic moments. The result was expressed graphically, showing that A's magnetic moment decreased from the first, while B's first increased to a maximum and then decreased. Thus B has a thin external shell of opposite polarity to the interior. When the magnets are exchanged in the spirals, this thin shell is magnetized in the same sense as the interior, while A suffers reversal of polarity on its exterior. Thus the magnetic moment of B increases and of A decreases. An explanation of this reversal was sought in the theory of the oscillatory discharge. This theory, first demonstrated mathematically by Sir Wm. Thomson, indicates that the period of the oscillation is lengthened by an increase of the capacity of the principal conductor. It is also lengthened by increasing the capacity of the discharger. Now the longer the period of the oscillation the greater the magnetic impulse produced by the discharge. This explains the reversal in B, since the capacity of its branch was much greater than that of the other. Experiments were made with conductors of different capacities; and the result, shown graphically, confirmed the indications of theory. The conclusion is that while B always shows a greater intensity of magnetization than A, the difference is probably due to difference in the periods of oscillation rather than to an unequal division of the discharge between the two branches.

THE RELATION OF VANISHING AND PERMANENT MAGNETISM. By Prof. H. W. EATON, Louisville, Ky.

[ABSTRACT.]

JAMIN found the following laws:—

1. The amount of the vanishing magnetism produced by a current is independent of the amount of permanent magnetism already present.

2. The decrease of the permanent magnetism of a bar by a current of the strength—i is independent of the amount of magnetism already present, and is double the permanent magnetism which the current $+ i$ will produce in the neutral bar.

Wiedemann and Chowolson obtained conflicting results.

Nine series of determinations with magnetizing currents of different strengths show that Jamin's first law holds good only when the bar is nearly saturated with magnetism. Wiedemann's results show that his bars were not thus saturated and this accounts for the different results obtained.

Sixteen series of tests show that Jamin's second law is approximately true when the demagnetizing current is one hundred or more on the scale used, but for weaker currents the law does not hold good.

NTROPY. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

THE LIFE OF THE UNIVERSE. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

A NEW HARMONOGRAPH. By Prof. CHAS. H. CHANDLER, Ripon, Wis.

NOTE ON ELECTROMETERS AND ATMOSPHERIC ELECTRICITY. By Prof. T. C. MENDENHALL, U. S. Signal Service Office, Washington, D. C.

ELECTROLYSIS OF SALTS OF THE ALKALIES AND ALKALINE EARTHS. By A. J. ROGERS, Milwaukee, Wis.

EXHIBITION OF A COMBINED SPECTROPHOTOMETER AND OPHTHALMOSPECTROSCOPE. By Prof. C. K. WEAD, Univ. of Michigan, Ann Arbor, Mich.

WEATHER CHANGES OF LONG PERIOD. By Dr. H. HELM CLAYTON, Ann Arbor, Mich.

THE DIRECT OPTICAL PROJECTION OF ELECTRO-DYNAMIC "LINES OF FORCE." By Dr. J. W. MOORE, Easton, Penn.

THE OPTICAL PROJECTION OF ELECTRO-DYNAMIC PHENOMENA. By Dr. J. W. MOORE, Easton, Penn.

EXHIBITION OF AN APPARATUS FOR DEMONSTRATING THE LAWS OF FALLING BODIES. By Prof. C. J. REED, Burlington, Ia.

SECTION C.

CHEMISTRY.

ADDRESS

BY

WM. RIPLEY NICHOLS.

VICE PRESIDENT, SECTION C, CHEMISTRY.

CHEMISTRY IN THE SERVICE OF PUBLIC HEALTH.

In attempting to comply with that clause of our constitution which requires the several vice-presidents to give addresses to their respective sections, I propose to speak briefly of

CHEMISTRY IN THE SERVICE OF PUBLIC HEALTH.

It may seem to some that it would be more fitting on such an occasion as this, either to review the progress of our science for the last year or for a series of years, or else to speak upon some subject of general theoretical interest. If any are inclined to criticise my choice of that branch of applied chemistry with which I am most familiar, I trust they will consider that, after all, few of us have the opportunity or—let us confess it—the ability to carry research and speculation to the highest regions to which chemistry is capable of rising. With the chemist, as with other men, the particular line of work is not determined solely by choice but often by force of circumstances, but there is no reason why we should not all have the true spirit of science, the intelligent desire for truth as yet unachieved, searching for it as we can and making honest use of it when acquired, even if we sometimes feel that other walks in our chosen profession are higher than those in which our own lines have fallen.

We are born men before we become scientists and, although the attractions of pure science studied for its own sake may be very great, the application of the truths acquired to the good of our fellow-men ought not to be considered as in any sense belittling to our science. While all the sciences may thus be expected to contribute to the general good, there is peculiar appropriateness in chemistry's being called upon to serve the public health, because

many of the dangers to which the public health is liable result from the industrial and other applications of chemistry itself. One of our own poets[1] has said, "for artificial evils, for evils that spring from want of thought, thought must find a remedy somewhere." How often the story repeats itself of a chemical industry, valuable in itself, established either without regard to the effect on the public or in a locality where for the moment there seems to be no public but which long in advance of anticipation becomes more or less thickly settled. In such cases, it is right that chemistry should afford a remedy.

The study of hygiene,—the study of the surroundings and influences which affect the public health must involve a study of those surroundings in their normal condition and of those objects or circumstances which interfere with their working or which create conditions which are abnormal. We are thus involved in a study of the air about us, its normal composition and the changes which that composition undergoes on account of the crowding together of individuals or on account of the pursuit of manufacturing industries. Nor can we be content with a study of the atmosphere about us: there is the atmosphere beneath our feet—the ground air—which also forms a subject for investigation. The water that we drink and that which we defile either by our own excreta or by the refuse of our manufactories, the food that we eat and the adulterations to which it is subject, the clothes that we wear, the houses that we inhabit, the pavements that we tread,—these are some of the subjects which the student of sanitary science has to consider, and in connection with all of them, chemistry is competent to lend valuable aid. With the intention of returning to some of these points in more detail hereafter, we pass on to note that

In the service of sanitary science, chemistry has an educational office to fill.

The public has very little conception of what the capabilities and limitations of chemistry are. A person asks you "What will it cost to analyze some eggs?" another wishes to know what it will cost to analyze a *gallon* of water; another cannot understand why, when water has been brought in a dirty jug, the chemist cannot distinguish between the dirt of the jug and the dirt of the water, and express an opinion as to what the quality of the water would

[1]James Russell Lowell.

be if it were brought in a clean vessel. Again in such a matter as the adulteration of food, there is a field for chemical instruction, a chance to demolish many fallacies. It is almost impossible for the (chemically) uneducated public to understand that when chemical action takes place, the properties of the substances concerned are not carried into the product. Thus, because carboys of that horrible substance known as "vitriol" are carried into glucose factories, it is difficult to persuade the average observer that the finished product does not possess the corrosive qualities of the acid, and even more dreadful is the use of *aqua fortis* in the manufacture of oleo-margarine. I remember a strong temperance argument against the use of manufactured liquors, one of the chief points in the indictment being the horrible causticity of spirit which had been rectified over quick-lime.

There must needs be reformers and philanthropists, I suppose, and it must happen, I suppose, that many of them are extremists,—and nowhere more than in sanitary matters is a little knowledge a dangerous thing. At the present moment the *microbes* or *bacteria* are prominent in the minds of such extremists and are the bugbears which make our continued existence in this life a constant miracle: a short time ago it was a something having a definite and well-characterized existence only in the minds of the terrorists, and designated by the name of "sewer-gas;" frequently it has been the adulteration of food.

The microbes, we are content to leave to the biologists; they may discuss them and educate the public into the idea that there are beneficent as well as pathogenic micro-organisms; perhaps the emanations from ill-kept drains and soil-pipes may be relegated to the same scientists since chemistry has failed to discover in the gases any chemical substance which can produce the specific effects ascribed to them. The worst of all this terrorism is that there is usually something of truth at the bottom of the scare; there *are* pathogenic microbes, and persons *have* been made sick by the emanations from drains. In the matter of food adulteration, the origin of the error is often obvious. Thus tea is said to be adulterated with prussic acid; at first we may be inclined to laugh at the idea, but then we see how it arose from the use of Prussian Blue in the facing. To bring the truth out of that which is largely false and to distinguish between adulterations which are harmful and those which are simply fraudulent, is a task which

all chemists have periodically to take up. There are points at which we are ourselves at fault. "Lime is a very caustic substance; its action on the skin is familiar; does this sample of glucose contain any lime?" "Oh, no!" "Sulphuric acid — why, that is vitriol; does the glucose contain any of that corrosive acid?" "Oh, no!" and yet if we make an analysis of the sample we are very likely to report *so much lime* and *so much sulphuric acid* present. Again, in the use of the term *impurity* are we not in fault? What do we mean by the "total solid impurity" in a water? What is there impure about gypsum, either solid or in solution? Or about carbonate of lime or chloride of sodium? What is a *pure* baking-powder? What is there impure about alum or carbonate of ammonia or acid phosphate of lime?

It is not only with regard to the adulterations of foods that popular fallacies exist. Thus in our school-days we were taught that the worst air in a room is at the bottom, and some of us were even told that if a lighted match were dropped in a crowded theater it could do no harm as, before reaching the floor, it would be extinguished by the accumulated carbonic acid. We are taught better now-a-days, not simply as a result of theoretical reasoning, but as a result of the actual experiments of such men as Pettenkofer and his pupils and assistants.

It is perhaps not altogether to our credit that we so often need the spur of extravagance to lead us to lay before the public the truth with regard to existing evils. The reason is obvious: few of us can afford to bear the expense of the investigations which must be made in order that we may speak with confidence, and our unvarnished and unexaggerated statement of things as they really are, cannot awaken that public interest which arises when people imagine after each meal that they feel the astringent effect of the alum in the bread, the burning sensation of the lime or vitriol in the glucose-adulterated sugar and the heavy weight of the clay out of which the coffee berries were moulded.

It is certainly an important service to public health — that of investigating the actual condition of existing evils—

And we would not leave the impression that the motion always comes from extravagant reformers and professed philanthropists, or that the truth is always reached by a rebound from a too advanced position. We can hardly, for example, bring the charge of extravagance against the investigation of the *Lancet* (1851–

1854) into the character of articles of food sold in London, which was made by Hassall, and which formed the foundation of his "Food and its Adulterations" (London, 1855); a work which is still regarded as an authority, and of which a new edition was published as late as 1876. Again, if one reads the easily accessible evidence given in England before parliamentary committees and commissions with reference to the passage of various bills in the interest of public health, it is apparent that chemists, as such, have exercised a great influence in modern sanitary legislation. This leads to another point where chemistry comes advantageously in contact with public health — namely:

In suggesting practical remedies for existing evils,— the office of chemistry being constructive as well as destructive.

These evils spring not from natural but from artificial causes; some one is responsible for them, and draws pecuniary benefit from them.

Some seem to believe that the proper method of proceeding in all cases is to ascertain the existence of the offence, and then to order its discontinuance at any cost, leaving the offending parties to devise their own remedies, or, it may be, to cease altogether from a profitable manufacture. This method may be applicable in some cases, especially in those which are *acute*, and where the interests opposed to the public health are of small relative importance: thus, if a manufacturer is discovered casting large quantities of some arsenical residues into a small stream or pond used for water supply, or if a newly established manufactory sends forth acid or other unwholesome or disagreeable vapors, to the detriment of a neighborhood where it has been deliberately built, no consideration of individual hardship should stand in the way of the public good.

The method of action must, however, be different in *chronic* cases. Where the evil has been long growing, or is of long standing, or where the conditions or surroundings have materially altered since an industry was established, or where large pecuniary interests are involved, such summary legislation is as a rule unjust. While we do not mean that the enactment should specify all the details of method by which the law may be complied with, it should at least, have in view, in a general way, a practicable solution of the difficulty, and especially with reference to chemical trades and chemical nuisances, it is for chemistry to say what is practicable.

As an example of successful sanitary legislation, and, at the same time, to a certain extent, as an example of chemistry repairing, or, at least, mitigating the damage of which chemistry has been guilty, we may take the passage and operation of the Alkali Act of 1863 in Great Britain. The neighborhood of an English alkali work is not one that a perfectly free agent would be likely to choose for a dwelling-place, but what must it have been when torrents of hydrochloric acid, which are now condensed, were allowed to pour forth into the air? Referring to the ante-alkali-act days, the first inspector, Dr. Angus Smith, said:

"Some years ago as is well known the escape of the whole [of the hydrochloric acid] was allowed; but as the manufacture increased the public complained more and the alkali makers erected condensers. Besides this cause the value of the muriatic acid had gradually been increasing and its condensation had in some places become a source of profit. Nevertheless it is true that thorough condensation was known to very few and practised by still fewer up to the time of the passing of the Act, and it even happened for some time after inspection had begun, 40 per cent of the gas was allowed to escape whilst 16 was a very common amount.[2]

"If we estimate the escape of muriatic acid at 1,000 tons per week before the passing of the Alkali Act, or at least before the introduction of the Alkali Bill into Parliament, we may be considered as taking a very moderate view of the question. * * * This quantity amounts to 208,000 tons per annum."

The Alkali Act of 1863 required that every alkali work should condense "not less than 95 per centum of the muriatic acid gas evolved therein." After the operation of the Act for one year, the actual average condensation throughout the kingdom was 98.72 per cent and the escape of dry acid reduced to 43 tons per week.

While the legislation itself was not a chemical problem, to accomplish this change it was necessary that processes of chemical manufacture should be improved, and it was further necessary to develop a system of inspection which should hold the manufacturers to the allowed limit. For this it was necessary to devise means for the frequent determination of what might be a very small proportion of hydrochloric acid in large volumes of other

[2] Alkali Act, 1863. First Annual Report by the Inspector of his Proceedings during the year 1864. Page 7.

gases and the methods employed had to be such as to command the confidence of the manufacturers.

On the other hand impracticable legislation is well illustrated by the history of the sewage difficulty in England. Towns were compelled to construct sewers and then forbidden to discharge them into the natural water courses, no one having any clear conception of how such discharge could be avoided, and hundreds of thousands of pounds have been spent in abortive efforts to obtain, comply with and evade legislation.

The chief fault which has been found with the Rivers Pollution Commission of 1868 is not with the research which they carried out, which was very thorough, nor with the elaborate method of analysis, which other chemists have not followed, but with the standards which they proposed and which, it was claimed, were quite unpracticable as they would in many cases require a manufacturer to discharge a waste liquid purer than the stream into which it was discharged, purer, in fact, than the water originally taken.

At this point it may not be unprofitable to notice a few among the many names, prominent in one department of chemistry or another, who have interested themselves in matters connected with the public health. We will not look earlier than the time when, according to Wurtz, "the French science of chemistry" was founded by Lavoisier of immortal memory, although previous to that time what was thought to be chemistry was not idle in this direction. Lavoisier himself, as is well known, was not indifferent to the public weal in peace or in war nor was he slow to apply his chemical knowledge to the solution of practical problems.

Among the firm supporters of Lavoisier and associated with him in the preparation of that system of chemical nomenclature which, for so many years, admirably served the purposes of the growing science, was Guyton de Morveau. While now-a-days he is probably known more for his services to the *science* of chemistry, in his own time he was known quite as much by his advocacy and use of acid vapors for disinfecting foul air. His independent work, *Traité sur les Moyens de Désinfecter l'Air*, was translated into English and German and I believe into other languages and a number of papers on the same subject appeared in the *Annales de Chimie* (1802–1815) and thence in English and German periodicals. He studied the use of zinc for kitchen utensils and the still contin-

ually recurring question whether "manufactures which exhale a disagreeable odor may be injurious to health."

Fourcroy (1789) studied the nature of "litharged" wine, Berthollet (1801) the methods of preserving water for long voyages, Chevreul (1846) various chemical reactions which explain the hygiene of populous cities and (1856, 1862, 1870) methods of preparing and preserving food; Graham and Hofmann reported upon the use of acetate of lead in sugar refining (1850), upon the London water supply (1851), upon the adulteration of pale ales with strychnine (1882); Dumas was interested in many sanitary matters and made, among others, reports on the mineral waters of France (1851), on the water supply of Paris (1859), on the treatment of sewage (1867) and on the preservation of food (1870–72); Wurtz was for a number of years president of the *Comité consultatif d'hygiène* and a year before his death was president of the *Société de médecine publique*. His investigations and reports on sanitary subjects are numerous,—on the disposal of the waste from distilleries and sugar-refineries, on the colors employed on German toys and in articles of food, on the adulteration of wines, etc.

Other names will occur to us,—such as those of Sir Henry Roscoe, Sir Frederick Abel and Dr. Williamson who served on Noxious Vapours Commission of 1876; of Frankland who gave years of service to the Rivers Pollution Commission of 1868 and in connection therewith devised an elaborate system of water analysis: we think also of Schutzenberger devising a method for the determination of oxygen dissolved in water (not, to be sure, simply for sanitary purposes), Mallet studying the various methods of water analysis, Remsen studying the organic matter in the air and Leeds the practical effect of charging with oxygen (or rather with air) water used for purposes of domestic supply.

There are two names which cannot fail to come to our minds when we think of workers in the line of sanitary chemistry—Pettenkofer and Angus Smith.

Pettenkofer, to be sure, approaches the matter from a medical or rather from a physiological standpoint, but he and his students have shown brilliantly in the Munich laboratory how chemistry may be made to aid both physiology and hygiene. Pettenkofer's method for the determination of the amount of carbonic acid in the air remains to-day essentially unaltered and the studies based upon it and carried out by various students and assistants in his

laboratory have extended to the composition of the ground-air, to the effect of various illuminants on the air of confined places, and, recently, to the relative merits of the electric light in lighting theatres; also to numerous questions in connection with natural and artificial ventilation. The results of researches into the effect of sewers and privy-vaults upon the surrounding soil, into the porosity of building-materials, into the passage of illuminating gas through the ground, and papers on many similar subjects have appeared in the *Zeitschrift für Biologie*, and, more recently, in the newly established *Archiv für Hygiene*.

Even more to our purpose is the name of Robert Angus Smith who for the greater part of his life was devoted almost exclusively to sanitary chemistry. His investigations into the air of mines, his work as inspector under the Alkali Acts of 1863 and 1874 and more recently under the Rivers Pollution Act of 1876, his works on Air and Rain and on Disinfectants and Disinfection, and his studies on oxygen which were progressing at the time of his death, claim for him the respect of chemists and the gratitude of sanitarians.

In mentioning these names — to which many others might be added — the object has been to show that the problems of sanitary chemistry have not been thought unworthy of the attention of able chemists. It will, of course, be understood that few men would choose to follow sanitary chemistry exclusively if they were ambitious of a wide reputation as *chemists*, if they were ambitious, let us say, of eventually receiving a foreign honorary membership in the German Chemical Society. Few men of the ability of Angus Smith would devote themselves as constantly as he to this branch of the subject. Yet it is highly desirable that even the routine work, the ordinary investigation for sanitary purposes of water, air and food should be in the hands of chemists well-educated in their profession and imbued with the true spirit of science. It is, alas! too often the case that a smattering of the principles of chemistry and a brief course in analysis is held to justify a person in assuming the duties and responsibilities of an analytical chemist, a state assayer or a public analyst.

There are reasons why the pursuit of sanitary chemistry appears less attractive than other lines of the profession. The first is the large amount of routine work. Thus, to determine the normal composition of the air in a given locality or the slight variations

which are due to changed meteorological or other conditions there is necessity for repeated daily or more frequent analyses continued for months or even years. In the same way pollution of water or of air may be patent to the senses (especially to the so-called common sense), but the variation from the normal condition may show itself by such slight chemical differences that it can be made plain to a jury only by the evidence of a great number of analyses.

Another reason why much of the work of the chemist in sanitary matters is unattractive to a scientist is the low degree of accuracy which in many cases suffices and which, consequently, is made to justify approximate methods and—alas!—often slovenly work. It is not, for example, as a rule, of the slightest consequence whether a water yields 0.010 or 0.012 part of "albuminoid ammonia" in 100,000, or whether it contains 1.0 or 1.2 parts of combined chlorine, or whether there are 10.0 or 12.0 parts of total dissolved solids. The possible analytical accuracy is very much greater than the case demands and less interest attaches to the investigation.

Then, again, in certain lines of work, especially in estimating the amount of foreign (or certain foreign) substances in articles of food, the obligation to express an opinion with a show of accuracy about matters where accuracy is unattainable must create a feeling of disgust in the mind of a scientific man—at least until the hardening process takes place. The analysis of a series of milks from the same or from different animals may afford satisfactory employment and be made scientifically accurate, but what satisfaction in stating as an opinion that a given sample of milk contains such and such a percentage of added water? Or, in the examination of an article of food where different employed methods give in the same hands differences of five per cent, what satisfaction is there in maintaining a case against an adversary when the figures differ by ten per cent?

Then, again, there is the annoyance which has already been alluded to of the necessary contact with persons who are ignorant or unappreciative of chemistry or who regard it simply as a tool to subserve personal interests. To give some sort of an understanding of the results of chemical investigation, it is often necessary to use terms which do not mean to the chemist what they are understood to mean by the layman. There is also the annoyance

of having one's results and opinions quoted alongside of and as of equal value with those of some uneducated, unscientific, self-styled chemist. All this the student of pure science avoids in great measure and one who really loves the science is tempted to retire into his scientific cell and let the world take care of itself.

On the other hand, as an offset in a certain measure to these disadvantages, there are in the field of sanitary chemistry many problems for the solution of which special and delicate analytical and other methods must be devised, which involve careful chemical work and which bring results not only interesting in themselves but of actual practical benefit to the public. The consciousness of work well done brings satisfaction if it does not bring glory. Moreover, the work of the sanitary chemist seldom ends with the results obtained; the interpretation and utilization of the results are often the most difficult part of the problem and one with which the chemist alone is competent to deal.

I have been asked "What is sanitary chemistry? Is it anything more than puttering?" As if the problems were all solved and we had but to follow out a purely mechanical line of procedure guided by printed tables. But all the problems of sanitary chemistry are not yet solved and there is still opportunity for work on questions which have already long occupied the attention of chemists.

Our knowledge of the normal composition of the atmosphere, as far as the main constituents go, rests upon the analyses of numerous chemists — Bunsen, Gay-Lussac, Regnault, Boussingault, Lévy, and, more recently, Angus Smith, Jolly, Kreusler and W. Hempel; with reference especially to the varying relation of oxygen to nitrogen under changed barometric conditions I may refer to the careful work of our own Professor Morley. But, while we know so much, who knows what may be the bearing upon the health of the community of the slight natural variations to which the atmosphere is subject. How far do such variations and differences contribute to the reputed healthfulness of various localities? How far, if at all, to that which causes the evil reputation of other places, to much that is called malaria and to similar ills? How much in spite of the work of Angus Smith, Remsen and others do we know of the nature and influence of the organic matter of the air? It is only recently that the methods for determining

small quantities of carbonic oxide have become satisfactory and we are not yet agreed as to the limit at which its presence becomes of sanitary importance. Relying on the experiments of Vogel, Wolffhügel, Remsen[3] and others we now regard the passage of carbonic oxide through the heated iron of our cast-iron stoves and furnaces as one of the bugbears of the past, but if the amount of this gas in a heated room is too small to be of sanitary significance, who can tell us what are the composition and amount of the gaseous *somethings* which escaping—not necessarily through the heated iron but through dampers, feed-doors, etc.,—make the air of a house heated by anthracite so different from the air of a house heated by a wood-burning furnace? Although we hear a great deal about ozone, especially from medical men, and although thousands of estimations are made and recorded (mostly by the confessedly unreliable Schönbein test), what chemist hears the statements and reads the records without a skeptical shrug of the shoulders?

There is still much to be done in connection with the examination of air.

In the matter of the chemical examination of water we have seen methods change from decade to decade, and although the originators of several methods at present employed would lay great stress upon their value, we know from the studies of Professor Mallet[4] that all of them are open to criticism and improvement. It is thought and asserted by some that the day of chemical examinations is passing away and that the wholesomeness of a water is to be decided by biological rather than by chemical examination. There is no doubt that the general belief at the present time is that the *materies morbi* in waters which actually convey specific disease is organized,—that the *bacteria* or *microbes* or *microphytes* are the really injurious objects, and the method of analysis at present in the ascendant consists (essentially) in mixing a measured volume, usually but a fraction of a cubic centimeter, of the water with prepared gelatine and counting the number of "colonies" or "centers" developed after a certain time. The microbes thus developed may be further cultivated and

[3] Remsen's (Rep. Nat. Board of Health, 1881, p. 971) statement is that "in rooms heated by cast-iron stoves and furnaces there is not present in the immediate vicinity of the hot-air flues as much as 0.04 per cent of carbonic oxide." This was the limit of delicacy of the test employed.

[4] Rep. Nat. Board of Health, 1882, pp. 169-353.

studied by the use of high powers of the microscope and by various staining media and their pathogenic character established by experiments upon animals, but at present we are generally told simply the number of bacteria; already we find one water stated to be twice as good as another because by this method of procedure half as many bacteria per cubic centimeter have been found. Without detracting from the ultimate or from the present value of this or other biological methods of investigation we can not believe that they can replace chemical examination for a long time yet. In order that they should do so, it must become certain that all the evil effects of impure water are due to organisms recognizable by morphological or other characteristics and the number of microscopists capable of distinguishing these pathogenic from other harmless organisms must be very greatly increased. The mere fact that a certain water contains more or less than a certain number of bacteria in a cubic centimeter can not condemn a doubtful water nor remove from it what may be an unjust stigma. When the biological examination of water has been placed on a firm basis it will then be necessary to carry out the work begun by Professor Mallet of discovering the chemical characters which belong to waters which a biological examination condemns and of making these characters the basis of the chemical analysis. As long as we believe that, independently of discoverable bacteria, a contaminated water is unsuited for a beverage or for domestic use, so long the chemist will be called upon to discover evidences of contamination or to give assurance of their absence.

In the matter of the pollution of streams, especially by sewage, there is much chemical work to be done. The natural purification of streams is admitted to be a fact, but chemists differ very much in the extent to which it takes place and in the importance which is to be ascribed to the various agencies known to be at work. The action of oxygen has been and is to-day being studied from different points of view but clear light will not be obtained in the matter as long as we are content to speak of "organic matter" as though it were a definite something, nor until we have studied the action of oxygen in dilute solutions upon the individual chemical substances which make up the complex mass known as sewage.

Sanitary chemistry comes nearest to the great public in the ex-

amination of articles of food, drink and medicine. The complaint of adulteration is by no means a new one and laboratories have long existed in connection with customs or excise departments where certain articles have been subjected to analysis. Recent years have seen a greatly increased activity in this direction and in most countries legislation has become more particular and more stringent, and more or less adequate means have been provided for carrying out the provisions of the law; this has led also to the development of special methods for detecting adulterations.

In Germany, following upon the law of May 14, 1879, most of the larger cities and many of the smaller ones have established laboratories for the analysis of articles of food; these are at the service of the general public either gratis or under a tariff which is often ridiculously low. In Austria, the examinations called for by the law of April 30, 1870, are carried out in existing governmental or private laboratories. In France, several cities have opened municipal chemical laboratories; that of Paris is the prominent one and was opened, under its present management, on March 1, 1881. A force of more than twenty-five chemists is employed and the budget for 1883 amounted to 206,890 francs. The laboratory is at the service of the public, qualitative analyses — the results being reported simply in the terms good, passable, bad but not injurious, injurious—being made gratis; for quantitative analyses a moderate fee is charged. The statement that, during the year 1883, there were analyzed 14,627 samples requiring in all 87,762 individual determinations, will give an idea of the amount of analytical work performed.

In England, the Sale of Food and Drugs Act (1875, amended 1880) required the appointment of public analysts throughout the kingdom and called a large force into the service of the public health. At that time there were comparatively few persons really competent to undertake the varied analyses which would be called for by the spirit of the law and naturally enough some persons assumed duties which they were not competent to fulfil. Experience has, however, corrected many of the early evils, and the establishment of the Society of Public Analysts and the publication of such manuals as Allen's Handbook of Commercial Organic Analysis, Blyth's Manual of Practical Chemistry, and König's Chemie der menschlichen Nahrungs- und Genussmittel have done much toward the development and adoption of satisfactory methods

of analysis. New forms of adulteration are, however, from time to time devised and new food products and preservatives are continually coming into the market requiring study both from the physiological and from the hygienic standpoint.

In this country more or less stringent laws against adulteration exist in various States and these laws have in several States—New York, Massachusetts, New Jersey— been made more stringent on account of the popular feeling which was at its height in 1878-79. The means for carrying out the provisions of the law are, however, imperfect and the matter is usually in the hands of the State Board of Health, the extent of whose activity depends upon legislative appropriation and gubernatorial sanction. As far as I am informed, no laboratories have been established by States or municipalities where the public can have analyses made either gratis or for a moderate fee and it is doubtful how far the establishment of such laboratories is desirable. Experience has shown here and in other countries that private individuals do not care to spend even small sums in the investigation of the quality of what they eat and drink nor are they willing to appear in court against a discovered offender. Although the systematic inspection of articles of food and drink which are offered for sale is repugnant to our ideas of individual rights, it is only by some system of official inspection that the public can benefit by legislative enactment. In some of the States and larger cities the action of the Board of Health has been such as to make the law a protection to the well disposed and a terror to evil doers. The laboratories which exist in connection with various educational institutions are probably sufficient to accomplish all that is needed and there are advantages in securing the coöperation of a number of able chemists as is done in New York State and in assigning to each certain descriptions of articles for analysis. There is an American Society of Public Analysts meeting in New York and Brooklyn, but the term public analyst is not employed in the sense already established by English usage. The membership of the Society consists of those who are officially connected with Boards of Health—not necessarily chemists. Chemists engaged in the analysis of foods and drugs are, however, eligible for membership and chemical papers are presented at its meetings.

While to the public the analysis of food is the most prominent part of sanitary chemistry and the direction in which chemistry is

of the most obvious service, we would emphasize rather the work of the chemist in solving special problems of sanitary importance. Besides the laboratories established mainly for food analysis, there are many others in which are conducted chemical investigations in the interest of hygiene. Most laboratories established for other purposes—except for researches in pure chemistry—have more or less frequent occasion to undertake work in the line of sanitary chemistry—such, for example, as agricultural, pharmaceutical and physiological laboratories. Then there are the laboratories of various hygienic institutes, of which the most prominent—that of Pettenkofer—has already been mentioned.

It is in Germany that the greater bulk of this work of investigation is carried on. One of the first independent laboratories—if not the first—founded for the investigation of these questions is that of the Chemische Centralstelle für öffentliche Gesundheitspflege in Dresden. This laboratory was opened in January, 1871, under the present director, Hofrath Professor Dr. H. Fleck, primarily for the solution of such chemical problems as might be submitted to it by the police and other authorities. Analyses of food and other articles are also made for private individuals but the running expenses are borne by the state and it is understood that original investigations of a sanitary nature will be carried on by the director and his assistants. Among the subjects which have been investigated are various methods of water and food analysis, methods of rendering combustible materials uninflammable, the composition of the ground water and ground air in various localities including cemeteries, the composition of the air in buried coffins or in the neighboring ground and the character of the water draining therefrom, the permeability of soils to water and air, the pollution of streams, the effect of arsenical paper hangings upon the air of rooms; studies have also been made on disinfection and disinfectants, on natural and artificial ventilation, and on the ventilation of particular buildings. The results of these investigations are published in scientific periodicals and in the Jahresbericht of the institution; in some cases, also, in independent form. In our own country a great many such matters as these have been studied by individual chemists under the auspices of various Boards of Health. The State Board of Health of Massachusetts led the way and the earlier reports of the Board contain papers on the pollution of streams, on the composition of sewage, on the ground air in certain

localities, on the ventilation of buildings and railway cars, on artificial flavoring extracts, on arsenical colors in their various applications, on food adulteration and on other subjects where chemists have carried on the greater part of the investigation. Other Boards of Health, although later in the field, have been similarly active.

In connection with other laboratories should be mentioned that of the Reichsgesundheitsamt in Berlin. Of the work of this laboratory, routine analyses of articles of food and of domestic use form no part, but the laboratory is devoted to the solution of chemical, physical and biological problems of various sorts bearing on the subject of hygiene.

The laboratory of the Observatory of Montsouris, in Paris, will close this imperfect list of localities where work is going on in the line now under discussion. The observatory was established in 1871 for the study of meteorology in its bearing on agriculture and hygiene; the chemical work forms only a part of the whole. Chemical and microscopical examinations have been made of the waters which are used for domestic supply; of the Parisian ground water; of the emanations from the soil and from the sewers; on the air in different parts of the city. Regular chemical determinations are made of the ozone, carbonic acid and ammoniacal and organic nitrogen in the air; in the meteoric waters estimations are made of the ammoniacal and organic nitrogen, of the nitrogen in the form of nitrites and nitrates and of the organic matter oxidizable by permanganate of potash. Other determinations are made with less frequency. The results are published in a 12mo Annuaire at a nominal price.

It may be expected that I should say a word about the education of those who propose to follow more or less closely this line of work. The best preparation is a thorough knowledge of general and analytical chemistry and of general physics. I will say an *essential* preparation for I have no sympathy with rule-of-thumb methods. With such a foundation the student will find little difficulty in making special applications either to sanitary or to other matters. It may be desirable to modify the ordinary course in analytical chemistry so as to have it include methods of special interest to this class of students. This has been done at the Mass. Institute of Technology by the equipment of a separate laboratory and by offering a course of laboratory work involving a practical

study of the ordinary methods for the examination of water, air and certain sorts of food. Opportunity is also given for special research as in the laboratories of organic and of general analytical chemistry.

It should be distinctly understood that, while the term sanitary chemistry may be used for convenience for a branch of the subject which is occupying the attention of many workers, which has a copious literature of its own and which requires the application of certain special methods, the underlying chemical principles are the same as in any other application of the science. It is quite possible to take a bright lad from the grammar school or even from the street and teach him to make certain analytical determinations with great accuracy—but this does not make a chemist of him.

Courses in sanitary engineering are being opened in our technical schools. How these courses will develop, how far they will include the study of chemistry, does not yet appear. My own view of the matter would be to give to students in such courses, if possible, instruction in the general principles of chemistry, making use of illustrations appropriate to their chosen profession, the aim being to give them an intelligent idea of what questions should be submitted to the chemist and how the results obtained should be understood. I would not attempt to make chemists of them, neither would I encourage them to rule-of-thumb work. It is much more important for an engineer to know how properly to take samples of water for analysis than to know how the water is analyzed, more important to know how to interpret the results of analysis than to be able to perform the operations himself. For sanitary inspectors, it is not necessary that either engineers or chemists should be employed. Such inspectors should be familiar with certain chemical tests which should enable them to make preliminary examinations and to determine how far the aid of a chemist is necessary. If there is room in the community for a class of educated men (or women) knowing a little engineering and a little chemistry and a little biology and a little of other things, such an occupation is legitimate and honorable, but let us not call a man a sanitary engineer unless he is an *engineer*, or a sanitary chemist unless he is a *chemist*.

PAPERS READ.

CONTROL ANALYSES AND LIMITS OF RECOVERY IN CHEMICAL SEPARATIONS. By Prof. ALBERT B. PRESCOTT, University of Michigan, Ann Arbor, Mich.

EVERY day chemical determinations are made by methods the shortages of which are unknown. Results are checked against other results in parallel operations; processes are compared with other processes as to highest obtainable results; the operator does the best he can but has no factor of correction for inevitable deficiency. Certain operations in constant demand, in the service of industry and in pure science, such as the estimation of phosphorus in irons and the estimation of morphine in opiums, are rated by comparing results with each other, rather than measured by any standard of real truth. In many of these operations full control analyses are difficult to devise. In general, it may be said, trustworthy control operations are possible just to the extent that the material under analysis is capable of synthesis by the chemist. It must be his aim to make the artificial material identical with the original material in the following particulars. (1) All the chemical constituents of the one should be present in the other in like proportion; (2) the constituent to be estimated, as added in known quantity in the artificial material, should have the same physical condition as well as "chemical purity" that it bears in its quantity obtained from the original material; (3) the constituents to be separated should in each case hold the same relations of adhesion. Adhesion is in general resistance to separations, holding back the "traces" that lie between our results and complete work.

The control-analyses reported in this paper are such as have been resorted to at different times, to test methods wanted for investigations immediately in hand, and therefore they have not the unity of design that might characterize a series of trials wholly devoted to the measurement of methods.

I. RECOVERY OF STRYCHNINE FROM BREAD AND FROM MEAT.[1]

Qualitative Limits.

Limit of strychnine (sulphate) for "good" color test, from a series of seven graded trials,	0.0000025	gramme.
1. Recovering from 5 grammes bread, same limit, from a series of six graded trials,	0.0001	"
Strychnine not recovered from 5. of bread,	0.0000975	"
Limit of recovery for 1 part of bread,	0.0000195	strychnine.
Limit of recovery for 1 part of strychnine,	51282.	bread.
2. Recovering from 5 grammes meat, same limit, from a series of seven graded trials,	0.00016	gramme.
Strychnine not recovered from 5. of meat,	0.0001575	"
Limit of recovery for 1 part of meat,	0.0000325	strychnine.
Limit of recovery for 1 part of strychnine,	30769.	meat
2. Recovering from 50 grammes meat, same limit, from a series of three graded trials,	0.0004	gramme.
Strychnine not recovered from 50. of meat,	0.0003975	"
Limit of recovery for 1 part of meat,	0.00000795	strychnine.
Limit of recovery for 1 part of strychnine,	125786.	meat.

The strychnine was taken in solutions of known strength of the sulphate; the mixture with bread and meat was made by twenty-four hours maceration; the separation was accomplished by a uniform method including treatment with alcohol, repeated on the residue, following by repeated washing of the acidulated water-solution with chloroform, and thorough washing of the same solution, after making it alkaline, with portions of the chloroform. The qualitative test was applied to the dry residue by a drop of sulphuric acid and a just visible fragment of dichromate.

The twenty-four hours' maceration is designed to effect a degree of adhesion, only approaching that usual in the material under analysis for poison. In comparing the results of group 2, with those of group 3 of tests, it is remarkable that by working with quantities ten times larger, the ratio of recovery is made four times better. This indicates too great a degree of waste resulting from the manipulation, and implies that, especially in small operations, greater care should be taken in execution of every detail.

[1]These experiments make a part of an investigation, including trials of recovery from portions of the body after administration to animals, made by G. A. Kirchmaier, under the advice of the writer, and communicated in Contributions from the Chemical Laboratory, Univ. of Mich. II. Ann Arbor, 1883.

II. RECOVERY OF MORPHINE FROM BREAD AND FROM ANIMAL TISSUES.

Qualitative Limits.[2]

Limit of morphine (sulphate) for good color test,	0.00005 gramme.
1. Recovery from 64 grammes bread, same limit, from a series of four graded trials,	0.0004 "
Morphine not recovered from 64. of bread,	0.00035 "
Limit of recovery for 1 part of bread,	0.0000054 morphine.
Limit of recovery for 1 part of morphine,	185185. bread.
2. Recovery from 64 grammes membranous tissue, same limit, series of four trials,	0.0005 gramme.
Morphine not recovered from 64. of tissues,	0.00045 "
Limit of recovery for 1 part of tissues,	0.000007 morphine.
Limit of recovery for 1 part of morphine,	142857. tissues.
3. Recovery from 64 grammes liver, same limit, from a series of four trials,	0.0005 gramme.
Limits as in 2.	

Quantitative Limits.

4. Recovery from 128 grammes tissue (membranous), by Meyer's solution (1)—0.1 gramme	loses 0.01
(2)—0.05	" 0.003
With 128. of tissue, average loss of morphine,	0.0065
Average loss of morph. for 1 part of tissue,	0.000051
Average quantity of tissue for loss of 1 of morphine,	19608.
5. Recovery from 128 gramme liver, by Meyer's solution, (1)—0.1 gramme loses	0.0036
(2)—0.05 "	0.02
With 128 of liver, average loss of morphine,	0.0118
Average loss of morphine for 1 part liver,	0.000092
Average quantity liver for loss of 1 of morphine,	10870.

The morphine was taken in solution of the sulphate, of known strength; the mixture of morphine with bread, and with tissues, was made in the finely divided material, without digesting any time; and the separation was done by a constant method, as follows: The material was extracted with alcohol acidulated with sulphuric acid, the filtrate was neutralized and evaporated to a syrup, then diluted with acidulated water and filtered and washed, the filtrate was concentrated and then washed with amyl alcohol.

[2] These experiments were made under the author's direction, by S. G. Steiner, and were in preparation for experiments made in recovering morphine administered to animals.

The remaining washed (aqueous) solution was made slightly alkaline by adding ammonia, and extracted with amyl alcohol, by shaking out with repeated portions. The amyl alcohol solution was washed with a little water, and evaporated to dryness. For qualitative test, the residue was moistened with sulphuric acid and then drawn across with a sharp glass rod wet with nitric acid of specific gravity of 1.42. In the quantitative work the residue was taken up in water acidulated with sulphuric acid, and the solution titrated with Meyer's solution of potassium mercuric iodide.

The large waste of morphine in recovery shown by quantitative estimation accords with frequent experience of the instability of the alkaloid, and with the unsatisfactory results of estimations by Meyer's volumetric solution. On the other hand, the very small waste in the recovery shown by the qualitative results is at first surprising. Though the qualitative test itself was found to require twenty times as much alkaloid as sufficed for identification of strychnine, still it appeared that, in an operation only one-third larger, the recovery of morphine was made even more (one-seventh more) nearly complete than the recovery of strychnine. Had the morphine solution been macerated with the tissues twenty-four hours, as was done with the strychnine, the results might have compared very differently. But it is quite in accord with the results here quoted that morphine, though elusive from its instability, may interpose to separations less resistance of adhesion than does the more stable alkaloid strychnine.

III. Recovery of arsenic from liver.[3]

Quantitative limits.

In comparison of three modes of separation.

1. By corrosion with chlorate and hydrochloric acid, then precipitating as a sulphide.

(1) In 62 gm. liver, 0.00127 As O loses 0.00054–0.00087 per cent of liver.
(2) 0.00127 " " 0.00059–0.00095 " " " "
(3) 0.00127 " " 0.00054–0.00085 " " " "

For 1 part liver, average loss of As O -0.0000089.

Parts of liver, average for loss of 1 part As O_3—112360.

[3] These experiments were made, under the author's observation, by Mr. H. J. Holthoefer, in 1883, with the purpose of comparing the efficiency of three rival methods of separation, and the results were published in Contributions from the Chemical Laboratory of the Univ. of Mich., II. p. 87.

2. By distillation as arsenious chloride.

(1) In 62 gm. liver, 0.00127 As_2O_3 loses 0.00056–0.00090 per cent of liver.
(2) 0.00127 " " 0.00057–0.00092 " " " "
(3) 0.00127 " " 0.00059–0.00095 " " " "

For 1 part liver, average loss of As_2O_3–0.0000092.

Parts of liver, average for loss of 1 part of As_2O_3, 108695.

3. By corrosion with sulphuric and nitric acids, not precipitating as sulphide.

(1) In 62 gm. liver 0.00127 As_2O_3 loses 0.00032–0.00052 per cent of liver.
(2) 0.00127 " " 0.00034–0.00055 " " " "
(3) 0.00127 " " 0.00033–0.00053 " " " "

For 1 part liver average loss of As_2O_3–0.0000053.

Parts of liver, average for loss of 1 part As_2O_3–188698.

The arsenic was taken in a hydrochloric acid solution of arsenious acid, of known strength. After separation the arsenic was in each case estimated by weight of the " mirror " of elemental arsenic, reduced from arsine.

The separation of arsenic is, by either of these methods, entirely satisfactory. It appears that the precipitation as sulphide involves a loss, though very slight, that reduces the efficiency of the older method wherein this precipitation is employed. The qualitative limit of identification is nearly the same for arsenic that it is for strychnine, but the quantitative determination is very close for arsenic and not at all close for strychnine.

Finally, the summary next given may be further defined, in comparison of limits of separation with limits of identification, as follows, namely: The loss in separating from an avoirdupois pound of tissues, is, for arsenic, in round terms about a thousand times the quantity needed for certain identification; and for strychnine, from one thousand to two thousand times such least quantity. For morphine, both limits are less definite, and decomposition losses interpose, and the data obtained do not warrant an assured statement. But in the results here given the loss of alkaloid, per pound of tissues, was about one hundred times the quantity needed for identification.

SUMMARY OF LIMITS OF RECOVERY.

(Separation of Crystalloids from Colloids.)

Strychnine (24 hrs. mac.) from 5 gm. bread, 1 in 51282 parts, qual.
5 " meat, " 30769 " "
50 " meat, " 125786 " "

Morphine (not mac.) from	64 gm.	bread,	1 in	185185	parts, qual.
	64 "	tissues,	"	142857	" "
	64 "	liver,	"	142857	" "
	128 "	tissues,	"	19608	" quant.
	128 "	liver,	"	10870	" "
Arsenic (1) from	62 gm.	liver,	1 in	112360	parts, quant.
(2)			1 "	108695	" "
(3)			1 "	188697	" "

LIMITS OF RECOGNIZABLE PRECIPITATION.

The first production of a precipitate, in a mixture made by adding one solution to another, is a constant not agreeing very closely with that of the so-called solubility of the substance precipitated. The proportion of solvent needed to dissolve a solid may differ a good deal from the proportion of the same solvent present at the incipient precipitation of the solid. In other words, the equilibrium between precipitation and solution may offer a good deal of resistance—just as the melting point may be removed some degrees from the congealing point. It is true that the factor of solubility is usually—perhaps incorrectly—defined as the ratio obtained when a supersaturated solution, left at a certain temperature for a certain time, has deposited its excess of dissolved substance. Moreover, the causes of variable solubility of solids are very illusive. Results in illustration of such variability were given to this Association by the writer in 1875. Indeed, our ideas of solubilities are in a suggestive stage, leading us toward the unknown border between adhesion and chemism.

It appears to the writer that the fact of the initial appearance of a precipitate when one given solution is added to another, in stated conditions, may be taken as a constant by itself—not to be calculated from other constants but to be determined by experiment. Initial precipitation is governed by the concentration of the substance precipitated, by the presence of and concentration of other dissolved substances, and by temperature, and time. That is, with temperature and time we have relations of mass too complex for calculation now, but easily made constant in experiment. Now if we fix the temperature and time, the quantity of the one solution with its components and their concentration, and fix the quantity of the other solution and know its components, then the concentration of these components becomes constant in parallel opera-

tions. In short, by controlling the given factors, a simple qualitative test may be made to show whether a required percentage is at, or above, or below, a required limit. This way of using qualitative tests, with measured quantities, temperatures, and times, to reach quantitative indications is a resource becoming more and more common in analytical work. It is made available in the later revisions of the pharmacopoeias. For instance, in the U. S. Ph. "If 1 gm. of Bitartrate of Potassium be digested with 5 cc. of diluted acetic acid for half an hour, then diluted with distilled water to 500 cc., the solution agitated and filtered, and 25 cc. of the filtrate treated with 5 cc. of test-solution of oxalate of ammonium, the liquid should not become cloudy in less than one minute, nor distinctly turbid in less than one minute and a half (absence of more than 6 per cent of tartrate of calcium)." Likewise we have the test (Kerner's) of sulphate of quinine for other cinchona alkaloids, of iodide of potassium for chloride and bromide, and of bicarbonate of sodium for monocarbonate.

Two years ago, in an inaugural thesis for the master's degree in the University of Michigan, Delos Fall reported determinations of the limits of precipitation. His work embraced 241 satisfactory experiments, defining 48 limits in formation of 24 precipitates. The limits were chiefly determined for the time of five minutes. There is a wide field for work of this character. It gives support to studies in molecular science; it fixes data of service in daily operations; and it defines factors by which a ready trial reveals required limits of strength and purity of materials. In the tests by Mr. Fall, 25 cc. of the solution of known strength of a single salt were taken; 5 cc. of a reagent of given strength added, in a test-tube 2 centimeters wide, and the depth of the liquid was made to be 9 centimeters. The temperature was noted, and observations for incipient precipitation were taken at stated times. The beginning of precipitation was recognized, in most cases, by observing a figure of 35 dotted parallel lines to the inch, looking through the same depth of water to which same quantity of reagent had been added for comparison. I quote selections of Mr. Fall's tabulated reports, to present the method of investigation, and the character of the results reached. I hope he and others may continue the work, and that the whole may have publication at a future time.

TABLE XVII.

SALT EXAMINED.	GRAMS OF WATER TO 1 OF SALT.	REAGENT.	C. C. OF REAGENT.	TEMPERATURE C.	TIME IN MINUTES.	MENSTRUUM 2 CM. DEEP.	MENSTRUUM 9 CM. DEEP.
K_2SO_4	40	$CaCl_2$	10	15°	3	Slight pre.	Slight pre.
	80		5	15°	5	No pre.	No pre.
	80		"	15°	20	Slight pre.	Slight pre.
	80		"	100°	2	Heavy pre.	Heavy pre.
	100		"	15°	25	No pre.	No pre.
	120		"	15°	30	No pre.	No pre.
	120		"	15°	180	Marked pre.	Marked pre.
	240		"	100°	5	Distinct pre.	Distinct pre.
	300		"	100°	5	*Limit.*	Pre.
	350		"	100°	5	No pre. seen.	*Limit.*
	400		"	100°	5	No pre.	No pre.

TABLE VII.

$Pb(NO_3)_2$	100	H_2SO_4	2.5	37°	0.1	Heavy pre.	Heavy pre.
	300		"	41°	0.1	" "	" "
	400		"	38°	0.1	" "	" "
	800		"	40°	0.5	Pre.	Pre.
	1000		"	35°	0.5	"	"
	2000		"	38°	0.2	Faint pre.	Opaque
	4000		"	38°	1.	" "	"
	5000		"	36°	5.	*Limit.*	"
	7500		"	35°	5.	No pre.	Faintly opaq.
	10000		"	42°	5.	" "	*Limit.*
	12000		"	29°	30.	" "	*Limit.*

FROM TABLES XXIX, AND XXXI.

SALT EXAMINED.	GRAMS WATER TO 1 OF SALT.	REAGENT.	C. C. OF REAGENT.	PRECIPITATE FORMED.	GRAMS OF PRE. FROM 1 OF SALT.	TEMPERATURE, C.	TIME, MIN.	MENSTRUUM 2 CM. DEEP.	MENSTRUUM 9 CM. DEEP.	
K_2SO_4	300	$CaCl_2$	5	$CaSO_4$	0.7807	100°	5	Limit		Table XVII.
	350		5			100°	5		*Limit*	
$Pb(NO_3)_2$	5000	H_2SO_4	2.5	$PbSO_4$	0.9153	36°	5	Limit		Table VII.
	10000		2.5			42°	5		*Limit*	
	12000		2.5			29°	30		*Limit*	

FROM TABLE XXXIII.

PRECIP.	PRESENT IN MENSTRUUM.	TEMP. C.	PARTS OF WATER TO 1 PART OF PRECIP. AT THE LIMIT.	"SOLUBILITIES" AS QUOTED BY STORER'S DICT.
$CaSO_4$	K_2SO_4 and KCl	100°	483	388 to 500
$CaSO_4$	$CaCl_2$ and KCl	100°	244	
$PbSO_4$	H_2SO_4 and HNO_3	29°	14421	13000
CaC_2O_4	$(NH_4)_2C_2O_4$, NH_4Cl	100°	24728	500000
BaC_2O_4	$(NH_4)_2C_2O_4$, $NH_4C_2H_3O_2$	100°	5462	2500

THE CRYSTALS OF BUTTER AND FATS. By DR. THOMAS TAYLOR, Microscopist, U. S. Agricultural Department, Washington, D. C.

[ABSTRACT.]

SINCE 1876, when my first paper was published on Butter and Fats, in the *New York Microscopical Quarterly Journal*, I have devoted a good deal of time to the investigation of this subject, principally with the view of finding a method by which I could, by the aid of the microscope, distinguish butter from butter substitutes. As a result of many experiments, I find that a person experienced in the use of the microscope may distinguish the fats of various animals and of vegetables by following the methods herein described.

The experimenter should first procure a specimen of common lard. This is composed mostly of crystalline starry forms which represent the solid fat of the lard. Real lard is composed of these and the oil common to lard. In very hot weather, the crystals dissolve in the oil, and perfect crystals can only be obtained by cooling slowly to about 21°C.

Place a drop of sweet oil on a glass slide, with the point of a needle. Place a small portion of the lard in the oil, and mix them together. Place a glass disc over the lard and oil mixture and press gently. If held up to the light white granules will be seen when the temperature is not over 16°C. These are fatty crystals. Under a low power of the microscope it will be observed that these crystals have stellar forms with dark centres, and spines radiating from them. See figure 7.

To procure normal crystals of beef kidney fat, render a piece of this fat in an iron pan, without water. Strain, and add sufficient sweet oil to bring the fat to the consistency of butter. Cool slowly for a period of from twelve to twenty-four hours. Mount in oil as directed in the case of lard. The crystals in this case present quite a different appearance from those seen in lard. See Fig. 8. View them by polarized light, with and without selenite plate. The beef crystals, to be seen to advantage, require a power of at least 500 diameters, being very small, although they appear very interesting objects with a power as low as 80.

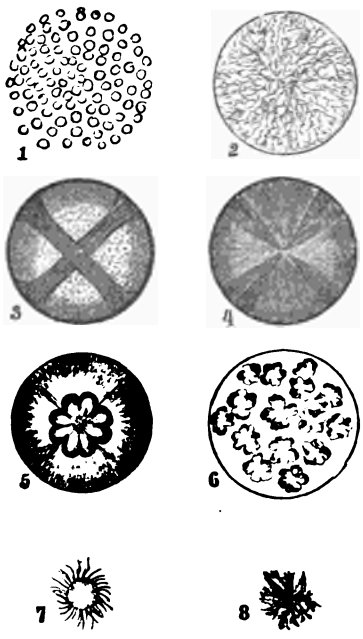
When it is desired to examine the crystals of butter, boil about

an ounce of pure, newly-made butter in a test tube or iron spoon for a period of several seconds; allow it to cool as directed in the case of beef and lard; place a few grains of it on a slip of glass; pour over it a few drops of alcohol (or better, alcohol nine parts, carbolic acid one part); separate the crystals with a needle, and view them with a pocket lens; they will appear like the eggs of insects, Fig. 1. Place a second portion of the same butter on a glass slide; combine it with a drop of sweet oil by means of a needle, reducing the butter to granules; cover with a disc of glass, and view first with plain transmitted light, when crystals like Fig. 2 will be seen. Second, by polarized light. In this case, place the polarizer low down and turn this prism round until its face angle crosses the face angle of the analyzing prism above. Under these conditions a dark ground is produced, and the butter crystals, which are globular in form, are seen in bold relief. The butter globular crystals will now exhibit a well-defined black cross, representing that known as St. Andrew's. See Fig. 3. Figure 4 represents a crystal of butter showing divisions produced in prismatic colors when the selenite plate is used with polarized light. If old butter or a poor oily butter is used in this experiment, the secondary crystals of butter are generally shown. These crystals are of rosette form, much smaller than that of the globular, and exhibit no cross. See Fig. 6.

The globular crystals of butter, when kept for a month or more, seem to bud like a vegetable spore, and frequently every round crystal will show projecting from each a smaller crystal. See Fig. 5. The globular forms generally vary from fifteen ten-thousandths of an inch to the one-hundredth of an inch in diameter. These forms are never seen in pure beef or lard fats. Care should be observed not to press the crystals flat, especially the globular crystals, as the cross is not seen when severely pressed.

Butter crystals vary slightly from each other in size and in some other slight particulars, such as color. A butter received from Tennessee, made from milk of Devonshire shorthorn and native breeds, shows on its crystals indentations, a condition represented in no other butter yet observed. The butter crystals seen in the butter made at Mr. Frank Ward's dairy, from milk of Alderney cows, of Washington, also differ in some particulars from all others examined, being darker in color, spines longer, and of larger size.

Specimens intended for permanent use should be mounted with a varnish ring, to prevent the cover from pressing on the crystals, and to prevent the movement of the cover used to protect them.



CRYSTALS OF BUTTER AND FATS.

Fig. 1.—Represents crystals of boiled butter as seen by a pocket lens.
Fig. 2.—A single crystal of butter, highly magnified, viewed by transmitted light only.
Fig. 3.—A crystal of butter viewed by polarized light only. It exhibits the cross of St. Andrew.
Fig. 4.—A crystal of butter as seen under polarized light and selenite plate. In this case beautiful colors are displayed, while the cross is but faintly seen.
Fig. 5.—Represents what seems to be a budding butter crystal. See description.
Fig. 6.—Represents the rosette crystals of butter.
Fig. 7.—The crystalline form of lard.
Fig. 8.—The crystalline form of beef.

I have examined quite a number of animal and vegetable fats, and find thus far, that animals and vegetables of distinctly different genera, and even species, yield fats which give fattycry stals haracteristic of the animals and plants which yield them.

A COLORIMETRIC METHOD FOR THE ESTIMATION OF PHOSPHORUS IN IRON AND STEEL. By EDWARD D. CAMPBELL, Detroit, Mich.

[ABSTRACT.]

THE process consists essentially in the comparison of the color produced by the action of stannous chloride on the molybdenum contained in the phospho-molybdate precipitate obtained from the solution of the iron or steel, with the color produced by the action of stannous chloride on a solution of molybdic acid of known strength.

By the above process I obtained the results .078 per cent, .079 per cent, .080 per cent, .088 per cent from a sample of steel that gave gravimetrically .080 per cent and .083 per cent.

An estimation with duplicate can be made in 3½ hours. I have made one in 2 hrs. 50 min.

PARA-NITRO-BENZOIC-SULPHINIDE. By Dr. W. A. NOYES, University of Tennessee, Knoxville, Tenn.

[ABSTRACT.]

SEVERAL years ago Fahlberg, while working in Remsen's laboratory, obtained an imide $C_6H_4 < \begin{matrix} CO \\ SO_2 \end{matrix} > NH$, to which was given the name of benzoic sulphinide. Several derivatives of this substance have been prepared since then. Most of the salts obtained from these sulphinides have been considered as derived from ortho-sulphamine-benzoic acid, though recent work in Remsen's laboratory has shown that in some of these salts, at least, the *imide* grouping is retained.

Para-nitro-benzoic-sulphinide forms salts of the latter character. It was obtained by oxidizing the ortho-sulphamide of para-nitro-toluene, $C_6H_3 < \begin{matrix} CH_3 & 1. \\ SO_2NH_2 & 2. \\ NO_2 & 4. \end{matrix}$, with potassium permanganate in alkaline solution. Para-nitro-benzoic-sulphinide crystallizes in fine needles which fuze at 209°–210° (Cor.) and have an intensely bitter taste. The potassium salt $C_6H_3 < \begin{matrix} CO \\ SO_2 \\ NO_2 \end{matrix} > NK$, is anhydrous

and very difficultly soluble in water. The barium salt,

$$\left\{ C_6H_3 < \begin{matrix} CO \\ SO_2 \\ NO_2 \end{matrix} > N \right\} Ba + 3H_2O,$$

crystallizes in well formed short prisms.

ON THE ESTIMATION OF SMALL QUANTITIES OF ACETIC ACID OCCURRING WITH LACTIC ACID IN SOUR MILK OR KUMYS. By Prof. H. W. WILEY, U. S. Department of Agriculture, Washington, D. C.

[ABSTRACT.]

WHILE examining fermented milk for lactic acid the microscope revealed the presence of the acetic acid ferment. From this it was reasonable to suppose that the sour milk contained acetic acid. The amount of this acid, however, proved to be very small. Relying on its greater volatility I tried to separate it from the lactic acid present by distillation. In order to determine the reliability of the method I used skimmed milk to which known quantities of the two acids were added. I also made a large number of distillations in order to determine the percentage of the total acids given off in definite amounts of the distillate. The results are given in tabular form and show that the acetic acid in such mixtures can be estimated with considerable accuracy when the quantity present exceeds one-tenth of one per cent.

When the amount of the acid present is as little as .04 per cent, the total amount distilled over when the distillate amounts to 100 cc. and the liquid remaining in the retort to 15 cc. is only a little over 7 per cent of the whole.

When .09 per cent of acetic acid is present the total amount distilled over under similar conditions is a little over 18 per cent of the whole.

If the amount of acid present is .14 per cent, the total amount of the whole distilled over is about 22 per cent.

When the amount of acid is .18 per cent, about 27½ per cent of the whole are distilled over.

When the amount of acid is .27 per cent the total amount distilled over is a little over 30 per cent of the whole.

The general results of the work are represented by a graphic chart.

The paper also contains results of the separation of the two acids existing in unknown quantities in the samples analyzed; also the methods of determining the total acidity of sour milk are discussed and the preference given to the method of separating the casein by strong alcohol and titration of the acid in the filtrate using phenol-phthalein as indicator.

NOTE ON THE ESTIMATION OF WATER IN GLUCOSES, HONEYS, ETC. By Prof. H. W. WILEY and F. V. BROADBENT, U. S. Department of Agriculture, Washington, D. C.

[ABSTRACT.]

THE method employed consists in dissolving about two grams of the sample, weighed in a flat platinum dish, in about 5 cc. of 80 per cent alcohol. In case much dextrine is present a weaker alcohol must be used. A short stirring rod is to be weighed with the dish. After solution is complete about 15 grams of pure sand are poured into the dish from a weighing bottle and the bottle reweighed. The sand is prepared by igniting the pure white sifted sand, afterwards washing it with distilled water and drying it at 110°. When the sand is poured into the alcoholic solution of the sample the liquid rapidly permeates every part of it. The sample is now placed in a bath and dried for half an hour to an hour at 100°. It is then removed and after having cooled to about 70° is treated with from 5 to 10 cc. of absolute alcohol which is mixed up with the sample by means of the stirring rod as thoroughly as possible. After allowing to stand for a few minutes, the dish is warmed at 70° until the alcohol has almost all been driven off. It is then placed in an air bath at 100° and dried to constant weight.

Tables of results obtained by this method are given in order to show its accuracy.

HONEY AND ITS ADULTERATIONS. By Prof. H. W. WILEY, U. S. Department of Agriculture, Washington, D. C.

[ABSTRACT.[1]]

THIS paper contains the results of the chemical study of forty-two samples of honey purchased in the open market or obtained

[1] This paper is printed in full in Am. Apiculturist, Vol. III, p. 265.

directly from apiarists. The analyses are grouped together in five tables. In the first table are given those samples which were adulterated with starch sugar-syrup.

In the second those which were apparently adulterated with sucrose.

In the third are grouped those samples which on account of their high laevo-rotatory power appeared to have been adulterated with inverted sugar-syrup.

In the fourth are found those samples bought in the open market and which appear to be genuine.

In the fifth are collected those samples which were furnished by apiarists and believed to be genuine.

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COMPOSITION OF KUMYS MADE FROM COW'S MILK. By Prof. H. W. WILEY, Department of Agriculture, Washington, D. C.

[ABSTRACT.]

KUMYS, properly speaking, is fermented mare's milk. In this country, however, it is now largely made from cow's milk. The object of the investigation is to compare this American kumys with that made from mare's milk. For this purpose a number of analyses of American kumys were made. The percentages of carbonic and lactic acids, alcohol, water, albuminoids, milk, sugar and fat were determined. The methods of analyses are described. The results are presented in tabular form and a comparison made of the means obtained with those given for kumys made of mare's milk by English and continental analysts.

The kumys analyzed had been bottled only ten or twenty days and its percentage of alcohol would probably have been greater had it been allowed to stand longer before analysis. The samples had only about half as much alcohol as those analyzed in Europe and the percentage of milk sugar was consequently much higher.

The following are the means of the analyses of eight samples:

Carbonic acid,	0.83 per cent.
Lactic acid,	0.47 " "
Alcohol,	0.76 " "
Albuminoids,	2.56 " "
Fat,	2.08 " "
Milk sugar,	4.38 " "
Water,	89.32 " "

A CHEMICAL STUDY OF YUCCA ANGUSTIFOLIA. By HELEN C. DE S. ABBOTT, Philadelphia, Pa.

[ABSTRACT.]

THIS plant is well known in the west as the "soap-weed." It grows very abundantly in most of the western states and territories. It has attracted the attention of botanists, and it is a plant of interest on account of the many uses to which it has been put in the countries where it is found.

The only notices of chemical work on this plant which I have been able to find are the following: (1) In a paper[1] on the study of manganese found in the ash of plants, it was stated that the ash of the leaves of the *Yucca* contains manganese. The name of the species of *Yucca* examined was not given. (2) Dr. Georges Pennetier[2] has studied the micro-chemical characters of the action of iodine and sulphuric acid, dilute chromic acid, and ammoniate of copper on the fibres of the *Yucca angustifolia*.

[1] M. E. J. Maumene, Bul. de la Société Chimique de Paris, Tome XLII, p. 305.
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The characteristics of a true honey are discussed and comparisons made of the results of the analyses with the work of other investigators. A pure honey appears to contain about 18 per cent of water, 0.18 per cent of ash, 0.30 per cent of albuminoids, 71 per cent of reducing sugars, 2 per cent of sucrose and about 8 per cent of undetermined matters. At a temperature of 23° a pure honey has a laevo-rotation of about ten divisions of the cane sugar scale.

The three adulterants of honey which are most used are starch sugar-syrup, sucrose-syrup and inverted sugar-syrup. The methods of detecting these various adulterants are discussed and the preference given to double polarization combined with double reduction.

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The specimens used in my analyses were kindly sent by Dr. F. M. Endlich from Lake Valley, New Mexico. The bark and wood of the root, the green leaf and its yellow basal part were separately examined. The roots were air dried, reduced to a very fine powder and passed through a No. 80 sieve. The leaves were less finely powdered.

The plan for plant analysis suggested by Dragendorff[3] has been generally followed.

I.

Qualitative ash analysis of each of the parts of the plant showed the presence of iron, manganese, calcium, magnesium, potassium, sodium, chlorides, phosphates, and sulphates.

Determination of { (I) Moisture / (II) Total ash } on the original powder.

	I.	II.
(1) The bark of the root	6.788 per cent	17.38 per cent
(2) " wood " " "	11.670 " "	15.75 " "
(3) " green leaves	8.110 " "	5.75 " "
(4) " yellow base of leaves	37.000 " "	10.63 " "

[3] Plant Analysis, Qualitative and Quantitative, by G. Dragendorff. Translated from the German by Henry Greenish, London, 1884.

PETROLEUM SPIRIT EXTRACTS.

	Solids extracted.	*Character of residue.*	*Reaction with litmus.*	*Melting point.*	*Solidifying point.*
1. The bark of the root	1.24 per cent.	fixed oil	slightly acid	60° C.	Solid at ordinary temperature.
2. " wood " " "	0.55 " "	" "	neutral	36° C.	
3. " green leaves	2.20 " "	" " chlorophyll	acid	semi-fluid at ordinary temperature	15° C.
4. " yellow base of leaves	1.10 " "	fixed oil	faintly acid	" "	12° C.

ETHEREAL EXTRACTS.

	Solids extracted.	*Character of residue.*	*Reaction with litmus.*	*Melting point.*	*Specific gravity.*	*Substances soluble in ether and water.*	*Substances soluble in alcohol and ether.*	*Substances soluble only in ether.*
1. The bark of the root	3.16 per cent.	resin	acid	70° C.	1.091	traces	traces	. . . .
2. " wood " " "	1.70 " "	"	slightly "	70° C.	1.091	"	"	. . . .
3. " green leaves	1.25 " "	" chlorophyll	" "	80° C.	. . .	0.34 per cent.	0.15 per cent.	0.65 per cent.
4. " yellow base of leaves	1.70 " "	resin	" "	79° C.	. . .	0.80 " "	0.40 " "	0.50 " "

ALCOHOLIC EXTRACTS.

	Solids extracted.	*Character of residue.*	*Reaction with litmus.*	*Quantitative estimation of glucose.*	*Quantitative estimation of saccharose and other reducible compounds.*
1. The bark of the root	9.25 p. ct. 0.20 p. ct. ash	red coloring matter (crystalline)	neutral	0.619 per cent.	0.180 per cent.
2. " wood " " "	14.30 " 0.10 " "	resin, saponin	"	1.502 " "	0.929 " "
3. " green leaves	3.80 " 0.15 " "	" "	"	none	none
4. " yellow base of leaves	4.30 " 0.05 " "	" "	slightly acid	traces	traces

II.

The solids extracted by petroleum spirit from the four parts of the plant are identified as fixed oils; associated with a volatile principle (0.2 per cent) in *extract* (2), and with traces of chlorophyll in *extract* (3).

Fixed oil (1) was crystalline in structure. It was soluble in ether, chloroform, benzole, carbon di-sulphide, and amyl alcohol; incompletely soluble in cold or boiling alcohol. It was colored pale green by sulphuric acid of 1.634 specific gravity, and it was changed to a bright green color by calcium di-sulphide, but formed no emulsion with it. The fixed oil was saponified, and a white soap separated. This was decomposed and the fatty acids recovered. Glycerine was separated from the soap filtrate.

Fixed oil (2) was dissolved with difficulty in boiling 95 per cent. alcohol; it was hardened and discolored by absolute alcohol. It was not saponified. The residue obtained from boiling the fixed oil with alcohol was submitted to a fractional precipitation with magnesium acetate.[4] Crystalline solids were separated by this method. They melted at 85° C., and at 60° C., respectively.

Fixed oil (3) was soluble in alcohol, ether, chloroform, benzole, carbon di-sulphide, oil-of-turpentine, almond oil, glycerine, and slowly soluble in acetic ether. The presence of free fatty acids was demonstrated by a red color obtained on mixing the fixed oil with powdered rosaniline. It was colored dark green by syrupy antimony chloride. On adding to the fixed oil sulphuric acid of 1.475 specific gravity, and a small quantity of zinc, hydrogen was generated and the solubility of the oil in the acid liquid was accompanied by a rosy tint given to the solution.

Fixed oil (4) was crystalline in structure. It was soluble in warm absolute alcohol, in cold acetic ether, chloroform, benzole, amyl alcohol, ether, carbon di-sulphide, and glycerine. It was saponified, and a white soap separated. The fixed oil was colored dark brown by alcoholic ammonia. Ferric chloride and powdered rosaniline gave a violet-colored reaction with it.

These fixed oils differed in their physical character, and chemical reactions. This difference may be due to the presence of free fatty acids and glycerides in varying proportions in the four parts

[4] Loc. cit., p. 16.

of the plant. It is of interest to note that in the subterranean part of the *Yucca*, the oil extracted from the bark was solid at the ordinary temperature; from the wood it was of a less solid consistency; while the yellow base of the leaf contained an oil quite soft, and in the green leaf the oil was almost fluid.

III.

The residues from the *ether extracts* of the bark and of the wood of the root contained resins which were identified as the same compound. They correspond in color, melting point, specific gravity, solubilities, and reactions. The resin is a transparent, ruby-colored substance, crystalline in character, and of a softer consistency than ordinary resin. It was imperfectly soluble in 95 per cent. alcohol; soluble in boiling absolute alcohol, in cold ether, and amyl alcohol; not appreciably soluble in chloroform, benzole, carbon di-sulphide, and alcoholic ammonia. A blood red color reaction was obtained by warming the resin with a crystal of ammonium molybdate and a few drops of strong nitric acid.

The resin was examined by Hirschsohn's scheme.[5] It differed from all described resins in its reactions with the reagents used to identify them. This resin is a new substance, and it is proposed to name it yuccal.[6]

Another new resin was separated from the yellow base of the leaf. It was an opaque, reddish-yellow colored substance. It is proposed to name it pyrophæal.

White needle-shaped crystals were separated from the *ether extracts*. Tannin, gallic acid, glucosides, and alkaloids were not present in these *extracts*.

Alcohol extracted from the bark a red crystalline coloring matter which was separated in a pure state. It was precipitated from an aqueous solution by sub-acetate of lead, potassium bichromate, ferric chloride, ferrous sulphate, and formed a cloudiness with alum, and with stannous chloride solutions. The red color was brought out on addition of alkalies to a colorless solution. It was destroyed by acids.

[5] E. Hirschsohn. Watts Chem. Dict. Vol. VIII, pt. II. p. 1743.

[6] In my future examinations of plants should new resins be discovered, I intend to adopt for uniformity of resin nomenclature the termination *al*.

AQUEOUS EXTRACTS.

	Solids extracted	Ash.	Gum.	Ash.	Saponin.[7] A	Saponin.[7] B.
(1) The bark of the root	4.00 p. ct.	2.65 p. ct.	2.00 p. ct.	0.20 p. ct.	. . .	. . .
(2) " wood " " "	12.10 "	1.74 "	1.70 "	0.34 "	8.95 p. ct.	10.4 p. ct.
(3) " green leaves	4.35 "	0.40 "	0 77 "	0.12 "	. . .	. . .
(4) "yellow base of leaves	11.35 "	3.10 "	3.85 "	0.67 "	. . .	. . .

Several methods were tried for separating the saponin. The most successful method was to boil a mixture of 85 per cent. alcohol and the crude powdered wood. The solution was filtered and set on ice when a creamy white precipitate formed. It was purified by repeated boiling in 85 per cent. alcohol; on cooling, the saponin separated as a white powder.

Some of the results from the examination of the *aqueous extracts*, *dilute soda extracts*, and *dilute acid extracts* were as following:

(1). A new gum was separated.

(2). The aqueous extracts contained calcium oxalate, possibly brought into solution by saponin.

(3). The absence of starch in the bark and wood of the root, and the presence of inulin.

(4). The bark and green leaves contained calcium phosphate.

(5). The percentages of total albuminoids were calculated by estimating the amount of nitrogen present. The bark and wood of the root gave each 4.75 per cent of albuminoids and the leaves gave 9.62 per cent.

ON THE CONCENTRATION OF CERTAIN ACID RADICALS BY THE DIFFERENTIAL ACTION OF CHEMISM. By Prof. JOHN W. LANGLEY, University of Michigan, Ann Arbor, Mich.

[ABSTRACT.]

WHEN a metal plate is suspended in a solution capable of attacking it, there is a differential action between the plate and the components of the solution by which the acid radical, after union with the substance of the metal plate, becomes concentrated into a smaller space than it previously occupied.

[7] Two methods for the quantitative estimation. Plant Analysis, *loc. cit.*, p. 68.

In the case of copper in argentic nitrate the NO_3 has been experimentally found to divide into two parts, bearing to each other approximately the ratio of 1 to 3.

Copper in aqueous bromine produces a concentration of bromine, and zinc in aqueous bromine a still greater concentration. Also experiment proves that copper in solutions of ferric chloride and zinc in solutions of copper sulphate cause a concentration of the acid radical which takes place in opposition to the results which gravitation would be expected to produce. Also that this concentration is in some cases opposite to that which the law of diffusibility of salts would imply.

A provisional hypothesis is adopted that these experiments show chemism acting by linear attraction on distances greater than the radius of molecular attraction.

NEGATIVE BONDS AND RULE FOR BALANCING EQUATIONS. By Prof. OTIS C. JOHNSON, University of Michigan, Ann Arbor, Mich.

[ABSTRACT.]

1. Rule for determining bonds.
2. Rule for balancing equations.

(*a*) Simple oxidation.
(*b*) Oxidation with combination.
(*c*) Double oxidation.
(*d*) Complex oxidation.
(*e*) Equations in organic chemistry.

A SIMPLE METHOD OF FIXING CRAYON DRAWINGS ON PAPER. By Prof. F. P. DUNNINGTON, University of Virginia, Va.

[ABSTRACT.]

IT is frequently desirable to preserve drawings made on the blackboard, for purposes of illustration to class. All such drawings may be readily made with colored crayons upon unsized paper and then fixed by passing the paper through a bath of dilute varnish consisting of one part dammar varnish and twenty-five parts spirits of turpentine. The paper is then allowed to dry over night and may be handled and rubbed without blurring the drawing.

A SPONGE-LIKE MASS CONTAINING TITANIC OXIDE. By Prof. F. P. DUNNINGTON, University of Virginia, Va.

[ABSTRACT.]

A PIECE of a sponge-like mass which was found on a mountain side was exhibited to the Section. It is in a form suggesting that it had been fused and intumesced, being so light in mass that it will float in water. It is only to be fused in small pieces by a hot blast blowpipe and proves to have the same constituents as the soil beneath, viz.: ferric oxide, alumina, silica and titanic oxide, containing five per cent of the latter. It was suggested in the Section, that the formation resulted from a stroke of lightning.

A THERMO-CHEMICAL ANALYSIS OF THE REACTION BETWEEN POTASSIC HYDRATE AND COMMON ALUM. By Prof. A. V. E. YOUNG, Northwestern University, Evanston, Ill.

[ABSTRACT.[1]]

FROM the calorimetric and analytical experiments described in the above paper it is concluded:

I. That if potassic hydrate, in proportion varying from fifteen molecules to eight molecules, be added to one molecule of alum in solution there is established a chemical equilibrium between the soluble and insoluble portions which may be defined as follows: In a system consisting of aluminic oxide and sulphuric acid (So_3) there exists, for a given proportion of constituents (within certain limits), and for a given temperature and for a given degree of dilution (volume) a characteristic distribution of constituents between the soluble and insoluble portions of the system; if this distribution is disturbed in either direction, it tends to restore itself. If the system be constituted of aluminic oxide (Al_2O_3), sulphuric acid (So_3) and potassium hydrate (K O H), as obtained by adding from five to eight molecules of K O H to one molecule of alum, there is equilibrium between K O H on one hand and Al_2O_3 and So_3 on the other: such that, for a given proportion of unneutralized K O H, the precipitate has the same proportion of Al_2O_3 and SO_3 whether it be obtained by adding KOH to alum or by neutralizing with acid the alkaline solution obtained by adding ten molecules K O H to one molecule of alum.

[1] Printed in full in Proceedings Am. Acad., Boston, 1885.

II. That this distribution is a function of temperature and dilution as well as of mass, increase of either temperature or dilution tending to increase the basicity of the precipitate.

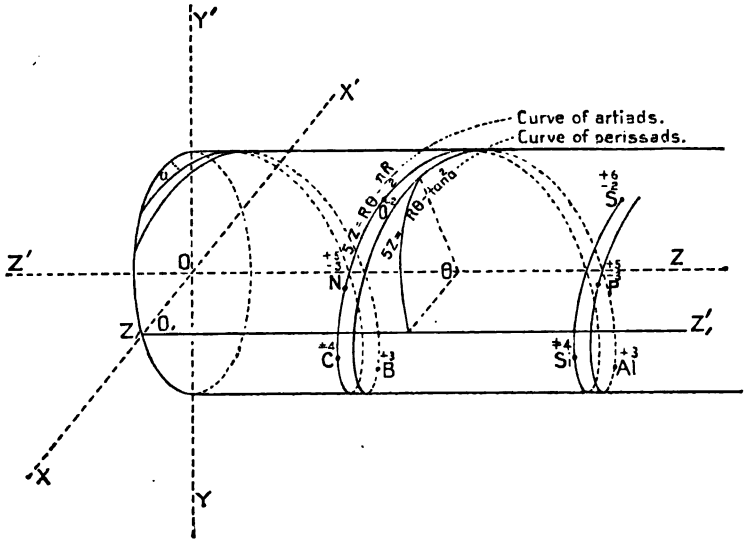
III. That these phenomena are probably due to dissociation by water of compounds of Al_2O_3 and SO_3 and of potassic aluminate, complicated perhaps by the formation and dissociation of an intermediate compound.

ON THE GRAPHICAL REPRESENTATION OF THE RELATION BETWEEN VALENCE AND MENDELEJEFF'S PERIODIC LAW. By C. J. REED, Burlington, Iowa.

[ABSTRACT.]

THE valence of the elements, like many other properties, has been shown by Mendelejeff to be a repeating function of their atomic weights.

If valence be represented by ordinates, the ordinates being positive for electro-positive and negative for electro-negative ele-



ments, and atomic weight by abscissæ, and a point be located for each element, these points fall on a series of double parallels.

By supposing this plane to be rolled around a cylinder, the several parallels unite to form a double helix, upon which the elements group themselves symmetrically in seven groups as shown in the figure, each group containing (theoretically) fifteen elements.

If the relations here indicated are real, we may reasonably conclude that valence is an *equicrescent rotary function* of atomic weight.

ON THE ACTION OF CARBONIC ANHYDRIDE IN AQUEOUS SOLUTION ON SOME OF THE MORE COMMON MINERALS; MODIFYING INFLUENCE OF THE PRESENCE OF CHLORIDE OF SODIUM. By Professor C. GILBERT WHEELER, Chicago, Ill.

[ABSTRACT.]

As all natural waters contain carbonic anhydride in solution and, in addition, a greater or less percentage of common salt, it becomes of importance to know the solvent action of such a solution on the more frequently occurring mineral species forming the crust of the earth. And as, further, the action referred to occurs under varying conditions of temperature and pressure, it seemed to me of much moment that *these* circumstances should also be carefully noted.

Up to the present, however, my experiments have been confined to the very frequently occurring minerals, calcite, dolomite and selenite. There is no doubt, though, that the larger number of the constituent minerals which compose the rock masses of the crust of the earth are capable of being more or less dissolved, or at least decomposed, by solutions such as we have under consideration. That even silicates are decomposed, the base being changed into either a carbonate or bi-carbonate, is generally recognized by chemico-geologists. The disintegrating, or decomposition, of the feldspathic rocks is a well known example of this action.

As far as the three minerals calcite, dolomite and selenite are concerned, I do not find that any attention has been hitherto given to the quantitative relations of their solubility in an aqueous solution of carbonic acid, except by Bischoff (*Chemical and Physical Geology*), by Lassaigne (Journ. Chim. Med., 1848) and by J. H. Tucker (Journ. Am. Chem. Soc., 1881), who have, however, not in addition experimented with a saline solution and on the

simple carbonic acid solution, limited their observations to one or two temperatures.

To obtain my solution I first saturated distilled water with carbonic acid, then added the finely pulverized mineral and allowed to remain therein, with frequent agitations, for from six to ten hours. Where salt was employed a saturated solution of this was first made, then saturated with carbonic acid as above. I used, invariably, the natural minerals, as the artificial compounds are more soluble and, besides, would not as well represent the actual facts in their relation to geological phenomena.

Solubility (expressed in grams per litre of solvent) of:

Temperature.	Calcite in		Selenite in		Dolomite in	
	Water + Co_2	Water + CO_2 + NaCl	Water + CO_2	Water + CO_2 + NaCl	Water + CO_2	Water + CO_2 + NaCl
0°C.			2.380		2.223	
10°	0.685		2.498		2.250	
20°	0.695	0.005	2.728	0.495	2.552	0.310
30°	0.710	0.055	2.730	0.945	2.650	0.365
40°	0.680	0.135	2.725	1.080	2.775	0.450
50°	0.475	0.220	2.705	1.230	2.800	0.530
60°	0.368	0.230	2.674	1.640	2.266	0.430
70°	0.316	0.215	2.654	1.920	0.980	0.399
80°	0.312	0.165	2.620	1.100	0.490	0.395
90°	0.300	0.054	2.600		0.426	
100°	0.298	0.010	2.570		0.422	

It may be further mentioned that the saturation with carbonic acid was each time effected at a temperature of about 15° C., and not only was the water saturated but the air above the liquid was uniformly displaced by the carbonic acid gas as well. The capacity of the vessel and the volume of liquid were, in each experiment, the same. After exposure, with frequent agitation, at the respective temperatures, the vessel remaining closed, the solution was maintained at the temperature of the experiment till perfectly clear, then a portion removed for quantitative examination.

ON THE ELECTRICAL FURNACE AND THE REDUCTION OF THE OXIDES OF BORON, SILICON, ALUMINUM AND OTHER METALS BY CARBON. By EUGENE H. COWLES, ALFRED H. COWLES and Prof. CHARLES F. MABERY, Case School of Applied Science, Cleveland, Ohio.

THE application of electricity to metallurgical processes has hitherto been confined chiefly to the reduction of metals from solutions, and few attempts have been made to effect dry reductions by means of an electric current. Sir W. Siemens attempted to utilize the intense heat of an electric arc for this purpose, but accomplished little beyond fusing several pounds of steel. A short time since Eugene H. Cowles and Alfred H. Cowles of Cleveland conceived the idea of obtaining a continuous high temperature on an extended scale by introducing into the path of an electric current some material that would afford the requisite resistance, thereby producing a corresponding increase in the temperature. After numerous experiments that need not be described in detail, coarsely pulverized carbon was selected as the best means for maintaining a variable resistance and at the same time as the most available substance for the reduction of oxides. When this material, mixed with the oxide to be reduced, was made a part of the electric circuit in a fire clay retort and submitted to the action of a current from a powerful dynamo machine, not only was the reduction accomplished but the temperature increased to such an extent that the whole interior of the retort fused completely. In other experiments lumps of lime, sand and corundum were fused, with indications of a reduction of the corresponding metal. On cooling, the lime formed large, well-defined crystals, the corundum beautiful red, green and blue hexagonal crystals.

Following up these results with the assistance of Charles F. Mabery, professor of chemistry in the Case school of applied science, who became interested at this stage of the experiments, it was soon found that the intense heat thus produced could be utilized for the reduction of oxides in large quantities, and experiments were next tried on a large scale with a current from two dynamos driven by an equivalent of fifty horse power. For the protection of the walls of the furnace, which were made of fire brick, a mixture of the ore and coarsely pulverized gas carbon was made a central core, and it was surrounded on the sides and

bottom by fine charcoal, the current following the lesser resistance of the central core from carbon electrodes which were inserted at the ends of the furnace in contact with the core. In order to protect the machines from the variable resistance within the furnace, a resistance box consisting of a coil of German silver wire placed in a large tank of water was introduced into the main circuit, and a Brush ammeter was also attached by means of a shunt circuit to indicate the quantity of current that was absorbed in the furnace. The latter was charged by first filling it with charcoal, making a trough in the center and then filling this central space with the ore mixture, which was covered with a layer of coarse charcoal. The furnace was closed at the top with fire-brick slabs containing two or three holes for the escape of the gaseous products of the reduction and the entire furnace made air-tight by luting with fire-clay. Within a few minutes after starting the dynamo, a stream of carbonic oxide issued through the openings, burning usually with a flame eighteen inches in height. The time required for complete reduction was ordinarily about an hour.

The furnace at present in use is charged in substantially the same manner, and the current is supplied by a Brush machine of variable electromotive force driven by an equivalent of forty horse power. A Brush machine capable of utilizing 125 horse-power, or two and one-half times as large as any hitherto constructed by the Brush electric company, is being made for the Cowles electric smelting and aluminum company, and this mach ne will soon be in operation. Experiments already made show that aluminum, silicon, boron, manganese, magnesium, sodium and potassium can be reduced from their oxides with ease. In fact, there is no oxide that can withstand temperatures attainable in this electrical furnace. Charcoal is changed to graphite; whether this indicates fusion or solution of carbon in the reduced metals has not been fully determined. As to what can be accomplished by converting enormous electrical energy into heat within a limited space it can only be said that it opens the way into an extensive field for both pure and applied chemistry. It is not difficult to conceive of temperatures limited only by the capability of carbon to resist fusion. The results to be obtained with the large Brush machine above mentioned will be of some importance in this direction.

Since the cost of the motive power is the chief expense in accomplishing reduction by this method, its commercial success is

closely connected with the cheapest form of power to be obtained. Realizing the importance of this point the Cowles electric smelting and aluminum company has purchased an extensive and reliable water power, and works are soon to be erected for the utilization of 1,200 horse-power. An important feature in the use of these furnaces, from a commercial standpoint, is the slight technical skill required in their manipulation. The four furnaces in operation in the experimental laboratory at Cleveland are in charge of two young men twenty years of age, who, six months ago, knew absolutely nothing of electricity. The products at present manufactured are the various grades of aluminum bronze made from a rich furnace product that is obtained by adding copper to the charge of ore, silicon bronze prepared in the same manner, and aluminum silver, an alloy of aluminum with several other metals. A boron bronze may be prepared by the reduction of boracic acid in contact with copper.

As commercial results, may be mentioned the production of 10 per cent aluminum bronze in the experimental laboratory with a daily average of fifty pounds, and it can be supplied to the trade in large quantities at prices based upon $5 per pound for the aluminum contained, the lowest market quotation of this metal being at present $15 per pound. Silicon bronze can be furnished at prices far below those of the French manufacturers.

A careful study has been made of the alloys which aluminum and silicon form with copper. An alloy containing 10 per cent of aluminum and 90 per cent of copper forms the so-called aluminum bronze with a fine gold color, which is quite permanent in the atmosphere. The tensile strength of this alloy is usually given as 100,000 pounds to the square inch; but castings of our 10 per cent bronze have stood a strain of 109,000 pounds. It is a very hard, tough alloy with a capacity to withstand wear far in excess of any other alloy in use. All grades of aluminum bronze make fine castings, taking very exact impressions and there is no loss in remelting, as in the case of alloys containing zinc. The 5 per cent aluminum alloy is a close approximation in color to eighteen carats gold and does not tarnish readily. Its tensile strength in the form of castings is equivalent to a strain of 68,000 pounds to the square inch. An alloy containing 2 or 3 per cent aluminum is stronger than brass, possesses greater permanency of color and would make an excellent substitute for that metal. When the

percentage of aluminum reaches 13, an exceedingly hard, brittle alloy of a reddish color is obtained and higher percentages increase the brittleness and the color becomes grayish-black. Above 25 per cent the strength again increases.

The effect of silicon in small proportions upon copper is to greatly increase its tensile strength. When more than five per cent is present, the product is exceedingly brittle and grayish-black in color. It is probable that silicon acts to a certain extent as a fluxing material upon the oxides present in the copper, thereby making the metal more homogeneous. On account of its superior strength and high conductivity for electrical currents, silicon bronze is the best material known for telegraph and telephone wire.

The element boron seems to have almost as marked an effect upon copper as carbon does upon iron. A small percentage increases the tensile strength of copper to 50,000 or 60,000 pounds per square inch without diminishing to any great extent its electrical conductivity.

Aluminum increases very considerably the strength of all metals with which it is alloyed. An alloy of copper and nickel, with a small percentage of aluminum, called Hercules metal, withstood a strain of 105,000 pounds and broke without elongation. Another grade of this metal broke under a strain of 111,000 pounds with an elongation equivalent to 33 per cent. It must be remembered that these tests were all made upon castings of the alloys. The strength of common brass is doubled by the addition of 2 or 3 per cent of aluminum. Alloys of aluminum and iron are obtained without difficulty; one product was analyzed containing 40 per cent of aluminum. In the furnace iron does not seem to be absorbed readily by the reduced aluminum when copper is present; but in one experiment a mixture composed of old files 60 per cent, nickel 5 per cent and of 10 per cent aluminum bronze 35 per cent, was melted together and gave a malleable product that stood a strain of 69,000 pounds.

When the reduction of aluminic oxide by carbon is conducted without the addition of copper a brittle product is obtained that behaves in many respects like pig iron as it comes from the blast furnace. The same product is formed in considerable quantities even when copper is present, and frequently the copper alloy is

found imbedded in it. Graphite is always found associated with it after the reduction, even when charcoal is the reducing material and analysis invariably shows a very high percentage of metallic aluminum. This extremely interesting product is at present under examination.

CHEMICAL CONVERSION SCALES. By W. A. WITHERS, State Experiment Station, Raleigh, N. C.

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SECTION D.

MECHANICAL SCIENCE

AND

ENGINEERING.

ADDRESS

BY

PROF. J. BURKITT WEBB,

VICE PRESIDENT, SECTION D.

THE SECOND LAW OF THERMODYNAMICS.

THE second law of thermodynamics will be the subject of this address, and its object will be to make clear what that law is, and to show that Rankine's statement of it is the only correct one, and, moreover, entirely comprehensible and easily demonstrable. After calling your attention to some statements as to this law and as to Rankine's way of putting it, no apology will be necessary for the choice of a subject, which ought already to have been fully and satisfactorily settled.

Professor Tait, quoting from Clerk-Maxwell, says: " . . . but when we come to Rankine's Second Law of Thermodynamics, we find that . . . its actual meaning is inscrutable.

" 'The Second Law of Thermodynamics.—If the total actual heat of a homogeneous and uniformly hot substance be conceived to be divided into any number of equal parts, the effects of those parts in causing work to be performed are equal.'

" We find it difficult, even in 1878, to attach any distinct meaning to the total actual heat of a body, and still more to conceive this heat divided into equal parts, and to study the action of each of these parts; but, as if our powers of deglutition were not yet sufficiently strained, Rankine follows this up with another statement of the same law, in which we have to assert our intuitive belief that—

" 'If the absolute temperature of any uniformly hot substance be divided into any number of equal parts, the effects of those parts in causing work to be performed are equal.'

"'The student who thinks that he can form any idea of the meaning of this sentence is quite capable of explaining, on thermodynamic principles, what Mr. Tennyson says of the great Duke—

'Whose eighty winters freeze with one rebuke
All great self-seekers trampling on the right.'"[1]

With all respect for the eminent physicist who gave this challenge, I would rather be responsible for these statements of the second law than for that with reference to his now celebrated "demon." "He will thus without expenditure of work raise the temperature of B and lower that of A, in contradiction to the second law of thermodynamics."[2]

Clausius gives as the "Second Fundamental Principle of the Mechanical Theory of Heat"—"Heat cannot of itself flow from a colder to a warmer body," and then applies it in thermodynamic investigations, and essentially this statement, perhaps because of its inviting nature, is given in some one of its forms by numerous authors as the second law of thermodynamics; now it may be a law in the general theory of heat but not in thermodynamics, which treats of the relations between heat and mechanical energy.[3] This is a very different statement from Rankine's; it is simple and plausible—deceptively so—and amounts to a statement that the universe is running down, which is by no means axiomatic or easily demonstrable.

The formula for the maximum efficiency of a heat-engine is sometimes given as the second law of thermodynamics; but this is a consequence only of that law and of the form in which any continuously acting heat-engine must necessarily be built. Rankine calls this the "law of the efficiency of elementary thermodynamic engines," and the manner in which it results from his second law is simple and evident; it is, however, more frequently made to depend upon Clausius's fundamental principle, or its equivalent, by an argument based upon the fact that a perfect heat-engine is reversible, and a significant remark of Professor H. T. Eddy's is to be noted here. " . . . The necessity for the existence of

[1] "Miscellaneous Scientific Papers: with Memoir of Rankine," by P. G. Tait, M.A., London, 1881. Page 30 of Memoir.

[2] "Theory of Heat:" by J. Clerk-Maxwell, M. A., London, 1877, page 328. (A and B stand for two portions of a uniformly hot and dense gas separated from each other by a thin wall).

[3] See Rankine's "Steam Engine," pages 223 and 209.

the second law is to afford a basis for Carnot's principle, and any truth which affords such a basis is called the second law."[4] This is anything but a dignified rôle for a law of nature, which should never hold a position except in its own right, and the formulæ of thermodynamics should not be made to depend upon truths chosen in this way.

A discussion of the various forms of the argument referred to would occupy too much space to form a part of this address, it may therefore be made the subject of a future paper. It is, however, to be remarked that the efficiency formula can be proved equally well on the supposition that heat will not flow of itself from a hot body to a cold one, or even that it will not flow in either direction,—we have only to reverse the pair of connected engines in the one case, or to run them in either direction in the other, to show the efficiency formula to be as correct as the hypothesis. It follows, therefore, that the truth of this formula is reflected in no degree upon the hypothesis of Clausius, and, further, this second fundamental principle, while it may be true, has nothing to do with the second law of thermodynamics as given by Rankine, except in such way as all natural phenomena may be connected. We may add also that the necessity for this form of argument has greatly diminished, perhaps disappeared, since Carnot's time, the discovery of the nature of heat having furnished us with the means of deducing the second law directly from a consideration of its action.

The preference, too, should always be given to the proof which is direct, and which exhibits the mechanism of nature—which follows her straight path and reveals her steps. The *reductio ad absurdum* and other indirect arguments should only be used tentatively until the direct chain of evidence may be traced, and no scientific mind should be satisfied with a demonstration which would compel belief without removing apparent objections.

There is, however, much evidence, besides that furnished by Professor Tait, that Rankine is not understood; his statements are either copied verbatim, without explanation, or modified in a way to make this evident. But Rankine is not so much to blame; statements on well-understood subjects are often in themselves quite unintelligible, and in new fields words and phrases are not

[4] "Thermodynamics," by H. T. Eddy, C. E., Ph. D., New York, 1879, page 18.

always at hand to completely express new ideas. Language is meant to excite and direct the imagination, and rarely does a form of words, when first heard, convey a definite and correct meaning unless the imagination meets it with pictures of all possible ways in which it may apply. Sometimes even it is necessary to understand the subject before statements in regard to it can be appreciated, and I must confess that before working up this subject myself, Rankine's statements were troublesome; now, however, they seem so reasonable that I shall endeavor to lead you to the same opinion and to convince you that of the three statements to which reference has been made, only Rankine's is indeed the second law of thermodynamics.

Let us inquire first what we should expect for the second law, after the first law has stated that heat and work are mutually convertible and convertible in a fixed ratio. It is manifestly appropriate that the second law state the agency by which such a conversion may be effected, and also the rate at which it will proceed.

To my classes in this subject I have for two or three years past given the following statement of the second law:—

A quantity of heat, W', may be employed as an instrument for the conversion of another quantity of heat, W, into work, or for the conversion of a quantity of work, A, into heat, and the converted quantity will be proportional to the convertor quantity for a given change of volume or of entropy.

To realize the meaning of this statement, let us imagine the simplest physical air-engine;—we need no fly-wheel, valves, etc., but simply a vertical cylinder of infinite height and unit section with non-conducting walls; the cylinder bottom must be permeable to heat and the non-conducting piston must be loaded with a pressure varying so as to be always but a differential less than the gaseous pressure beneath it. If we fix a finite limit to the total amount of heat which the engine shall be capable of transforming into work, then the height of our cylinder need not be infinite.

But this is no more than the shell of the engine;—we will suppose the piston to be at such a point that the cylinder shall have a volume of one cubic unit, and we will now put into it, say, one unit of mass of the molecules of a perfect gas;—the molecules may be supposed to be lying on the bottom, like dust, or they may be equally

distributed through the space, as in any gas, but they will be *devoid of motion*. We have now added the muscles, perfect in all respects, except that they are dead, and our engine is no more capable of performing its functions than would be a dead crab or lobster. The engine is not capable of transforming heat into work, for the reason that *the agent* by which such a transformation may be effected *is not present;* the space exists through which the piston may move, but, inasmuch as the molecules exert no pressure against the piston, there can be no question of work. Work is the product of force into space, and one factor, the characteristic one, is here wanting.

To obtain the needed pressure we must heat the molecules of the gas to the absolute temperature τ, *i. e.*, we must store in the molecules an amount of kinetic energy proportional to τ, and calculation shows that the pressure per square unit, which will then result from the rebounding of the molecules from the piston and walls of the cylinder will be proportional to this amount. It will also, should the volume be increased by changing the position of the piston, be inversely proportional to that volume. In the ordinary formula which connects the volume, pressure and temperature of a perfect gas,

$$pv = R\tau,$$

we have but to suitably change the value of R, say to R′, to be able to write

$$pv = R'W',$$

where p and v are the same pressure and volume as before, R′ a new constant and W′ the convertor quantity of energy, referred to in the law as given above, and which we have stored up in the mass of the molecules to act as the agent or instrument for the conversion of heat into work, or *vice versa*.

I wish to emphasize this point:—the engine consists of mass and energy, the mass being divided into two portions, viz., the metallic parts of the engine, which are made in the machine shop, and the molecular masses, which we will suppose to be supplied in the physical laboratory. The animal is not perfect without life, it is not an animal and cannot perform the functions of one, and so it is the stored-up energy, which is the real agent in the engine, and without which the engine may be said not to exist.[1]

[1]Rankine states somewhere that it is the working fluid which is the fundamental part of the engine, but I think that in this Rankine falls behind himself.

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With all respect for the eminent physicist who gave this challenge, I would rather be responsible for these statements of the second law than for that with reference to his now celebrated "demon." "He will thus without expenditure of work raise the temperature of B and lower that of A, in contradiction to the second law of thermodynamics."[2]

Clausius gives as the "Second Fundamental Principle of the Mechanical Theory of Heat"—"Heat cannot of itself flow from a colder to a warmer body," and then applies it in thermodynamic investigations, and essentially this statement, perhaps because of its inviting nature, is given in some one of its forms by numerous authors as the second law of thermodynamics; now it may be a law in the general theory of heat but not in thermodynamics, which treats of the relations between heat and mechanical energy.[3] This is a very different statement from Rankine's; it is simple and plausible—deceptively so—and amounts to a statement that the universe is running down, which is by no means axiomatic or easily demonstrable.

The formula for the maximum efficiency of a heat-engine is sometimes given as the second law of thermodynamics; but this is a consequence only of that law and of the form in which any continuously acting heat-engine must necessarily be built. Rankine calls this the "law of the efficiency of elementary thermodynamic engines," and the manner in which it results from his second law is simple and evident; it is, however, more frequently made to depend upon Clausius's fundamental principle, or its equivalent, by an argument based upon the fact that a perfect heat-engine is reversible, and a significant remark of Professor H. T. Eddy's is to be noted here. " . . . The necessity for the existence of

[1] "Miscellaneous Scientific Papers: with Memoir of Rankine," by P. G. Tait, M.A., London, 1881. Page 30 of Memoir.

[2] "Theory of Heat:" by J. Clerk-Maxwell, M. A., London, 1877, page 328. (A and B stand for two portions of a uniformly hot and dense gas separated from each other by a thin wall).

[3] See Rankine's "Steam Engine," pages 223 and 209.

the second law is to afford a basis for Carnot's principle, and any truth which affords such a basis is called the second law."[4] This is anything but a dignified rôle for a law of nature, which should never hold a position except in its own right, and the formulæ of thermodynamics should not be made to depend upon truths chosen in this way.

A discussion of the various forms of the argument referred to would occupy too much space to form a part of this address, it may therefore be made the subject of a future paper. It is, however, to be remarked that the efficiency formula can be proved equally well on the supposition that heat will not flow of itself from a hot body to a cold one, or even that it will not flow in either direction,—we have only to reverse the pair of connected engines in the one case, or to run them in either direction in the other, to show the efficiency formula to be as correct as the hypothesis. It follows, therefore, that the truth of this formula is reflected in no degree upon the hypothesis of Clausius, and, further, this second fundamental principle, while it may be true, has nothing to do with the second law of thermodynamics as given by Rankine, except in such way as all natural phenomena may be connected. We may add also that the necessity for this form of argument has greatly diminished, perhaps disappeared, since Carnot's time, the discovery of the nature of heat having furnished us with the means of deducing the second law directly from a consideration of its action.

The preference, too, should always be given to the proof which is direct, and which exhibits the mechanism of nature—which follows her straight path and reveals her steps. The *reductio ad absurdum* and other indirect arguments should only be used tentatively until the direct chain of evidence may be traced, and no scientific mind should be satisfied with a demonstration which would compel belief without removing apparent objections.

There is, however, much evidence, besides that furnished by Professor Tait, that Rankine is not understood; his statements are either copied verbatim, without explanation, or modified in a way to make this evident. But Rankine is not so much to blame; statements on well-understood subjects are often in themselves quite unintelligible, and in new fields words and phrases are not

[4] "Thermodynamics," by H. T. Eddy, C. E., Ph. D., New York, 1879, page 18.

always at hand to completely express new ideas. Language is meant to excite and direct the imagination, and rarely does a form of words, when first heard, convey a definite and correct meaning unless the imagination meets it with pictures of all possible ways in which it may apply. Sometimes even it is necessary to understand the subject before statements in regard to it can be appreciated, and I must confess that before working up this subject myself, Rankine's statements were troublesome; now, however, they seem so reasonable that I shall endeavor to lead you to the same opinion and to convince you that of the three statements to which reference has been made, only Rankine's is indeed the second law of thermodynamics.

Let us inquire first what we should expect for the second law, after the first law has stated that heat and work are mutually convertible and convertible in a fixed ratio. It is manifestly appropriate that the second law state the agency by which such a conversion may be effected, and also the rate at which it will proceed.

To my classes in this subject I have for two or three years past given the following statement of the second law:—

A quantity of heat, W', may be employed as an instrument for the conversion of another quantity of heat, W, into work, or for the conversion of a quantity of work, A, into heat, and the converted quantity will be proportional to the convertor quantity for a given change of volume or of entropy.

To realize the meaning of this statement, let us imagine the simplest physical air-engine;—we need no fly-wheel, valves, etc., but simply a vertical cylinder of infinite height and unit section with non-conducting walls; the cylinder bottom must be permeable to heat and the non-conducting piston must be loaded with a pressure varying so as to be always but a differential less than the gaseous pressure beneath it. If we fix a finite limit to the total amount of heat which the engine shall be capable of transforming into work, then the height of our cylinder need not be infinite.

But this is no more than the shell of the engine;—we will suppose the piston to be at such a point that the cylinder shall have a volume of one cubic unit, and we will now put into it, say, one unit of mass of the molecules of a perfect gas;—the molecules may be supposed to be lying on the bottom, like dust, or they may be equally

distributed through the space, as in any gas, but they will be *devoid of motion*. We have now added the muscles, perfect in all respects, except that they are dead, and our engine is no more capable of performing its functions than would be a dead crab or lobster. The engine is not capable of transforming heat into work, for the reason that *the agent* by which such a transformation may be effected *is not present;* the space exists through which the piston may move, but, inasmuch as the molecules exert no pressure against the piston, there can be no question of work. Work is the product of force into space, and one factor, the characteristic one, is here wanting.

To obtain the needed pressure we must heat the molecules of the gas to the absolute temperature τ, *i. e.*, we must store in the molecules an amount of kinetic energy proportional to τ, and calculation shows that the pressure per square unit, which will then result from the rebounding of the molecules from the piston and walls of the cylinder will be proportional to this amount. It will also, should the volume be increased by changing the position of the piston, be inversely proportional to that volume. In the ordinary formula which connects the volume, pressure and temperature of a perfect gas,

$$pv = R\tau,$$

we have but to suitably change the value of R, say to R′, to be able to write

$$pv = R'W',$$

where p and v are the same pressure and volume as before, R′ a new constant and W′ the convertor quantity of energy, referred to in the law as given above, and which we have stored up in the mass of the molecules to act as the agent or instrument for the conversion of heat into work, or *vice versa*.

I wish to emphasize this point:—the engine consists of mass and energy, the mass being divided into two portions, viz., the metallic parts of the engine, which are made in the machine shop, and the molecular masses, which we will suppose to be supplied in the physical laboratory. The animal is not perfect without life, it is not an animal and cannot perform the functions of one, and so it is the stored-up energy, which is the real agent in the engine, and without which the engine may be said not to exist.[1]

[1]Rankine states somewhere that it is the working fluid which is the fundamental part of the engine, but I think that in this Rankine falls behind himself.

Let us now see what is Rankine's last and most general statement, in which he generalizes the second law. "The effect of the presence in a substance of a quantity of actual energy, in causing transformation of energy, is the sum of the effects of all its parts." Here he distinctly places energy before us as the agent for the transformation of energy, and I believe that *nothing but energy can act as the agent*, and that the general law underlying all such transformations may be stated, perhaps, in the following form:

Every conversion of energy from a form A *into a form* B *can be effected only through the agency of a quantity of energy and* (I venture to add) *this agent, or convertor quantity, must possess at once the characteristics of* A *and* B.

In the air-engine the agent has temperature and pressure, respectively characteristic of heat and work; in the dynamo the field is characterized by both electrical and mechanical tension. In fact, this seems to me to be the only way in which we can logically conceive of such a transformation, and the only way in which observed transformations occur.

Now, our agent quantity of thermal energy must act without expense of energy to itself, for this is the peculiarity of agents, that they always make themselves safe when they do business for others; therefore the expansion must be isothermal, and a source of heat at the temperature $\tau + d\tau$ must be applied to the conducting bottom, so that the gas will be caused to expand with no loss of its own energy. In reality, *there is no other expansion than isothermal for the conversion of heat into work;* as to adiabatic expansion, it is never used for that purpose, nor can it be; it furnishes, simply, a means of lowering the temperature of the gas if the engine is made to run in a cycle, and the temperature may be lowered equally well by regenerator plates, the only difference being in the form in which the energy taken away from the agent is stored up. Adiabatic expansion does not take heat from the source and transform it into work, and the only expansion that does is isothermal; and in any mixed expansion it is only the isothermal element that is of any value for this purpose.

Now, the gas, in expanding from the volume unity to the volume v, converts a quantity of heat into work, and this quantity will be infinite when v becomes infinite. Also, for any given change of volume, say from v to v', the amount of heat changed into work

will be proportional to the pressure, that is, proportional *to the agent energy;* but this is just what the second law states, and the proof is therefore seen to be of the utmost simplicity, depending simply on the mutual proportionality of the work done, the pressure, the temperature, and the agent energy, or total actual heat (as Rankine calls it) of the working substance.

Let us look now at the behavior of the molecules; as each rebounds from the hot bottom its stock of agent energy receives into itself a portion of the heat W, which is to be changed into work; the molecule is driven away with increased velocity by the hotter, or more energetically vibrating, molecules of the bottom and carries its added energy to the piston, and gives only this quantity up in the form of work. The reason that it gives it up is simply that, if the piston be moving up with the velocity V, the molecule will rebound with a velocity reduced by 2V. As the volume increases the pressure falls, on account of the diminished frequency of the rebounds per unit of surface, and therefore the conversion of heat into work must proceed more slowly, but for any and all particular changes of volume the speed of conversion may be increased to any degree by means of a proportional increase in the amount of the agent. It is interesting, also, to notice the thing in another light; the energy has to be carried over the distance from the hot bottom to the moving piston, which distance increases directly with the increase of volume, and the time required to carry a certain amount will be increased as this distance increases; the way to secure a more rapid conveyance throughout is to increase the speed of the carrying molecules, *i. e.*, the amount of agent energy. Note also that the amount carried per molecule will be at the same time increased.

The molecules have been spoken of as moving directly toward and away from the piston, whereas they should move in all possible directions; it is well known, however, that this involves no error in the result, and scarcely one in the conception.

Let us see now whether there are any real difficulties in Rankine's statements. To understand them most easily, commence with his "General Law for the Transformation of Energy," already quoted, and proceed backward; we come first, then, to a graphical representation of the second law. After explaining the quantities in his diagram and stating the known relations between them, he requires us to suppose the temperature τ, to be divided into n equal

parts. Now, we can divide nothing except quantity into equal parts, and therefore Rankine regards temperature as a quantity, and so it is. We have only to remember that τ is the temperature of the agent, and therefore τ is the amount of agent energy in terms of a suitable unit; in fact, the statement that a unit mass of gas is at a temperature τ is equivalent to saying that it possesses τ units of thermal energy, the unit used being the energy required to raise this amount of gas one degree in temperature.

It is the agent energy, then, which we are to divide by n, and we are afterward told that the parts will be "similar, and similarly circumstanced." Let us suppose a molecule heated from absolute zero to the temperature τ, by adding n equal increments of energy, these increments can differ only in the order in which they may be added, and once added this distinction vanishes, and they become merged into the quantity of energy contained by the molecule.

On the scale of the thermometer the degrees all have their places, and the last degree added is necessarily the first one subtracted; but no similar conception can be applied to the energy of the molecule, and we can imagine no connection between the last increment added and the first subtracted, or any difference whatever between the increments, whose sum is the total energy of the molecule.

"Similar and similarly circumstanced" means, therefore, simply devoid of absolute and relative differences.

In this graphical treatment Rankine shows isothermal expansion, and his second law applies essentially to this expansion.

Rankine's next statement (proceeding backward) of his law is the second one criticised by Maxwell, and it supposes nothing more than the division of temperature already discussed. In some earlier editions the first formula under the statement is in error by the omission of τ; it should read

$$\tau \frac{d}{d\tau} = Q \frac{d}{dQ},$$

as it stands in the present edition.

We next come to a seemingly more general and comprehensible statement of the law which speaks of "the total actual heat." Now Rankine has defined this and it is simply the kinetic energy of the molecules, or that portion of the heat furnished to cause a rise of temperature from absolute zero to τ, which remains in the body as heat.

Inasmuch as Rankine's first statement of his law seems the more

general, insomuch has it led, as I believe, to a false comprehension of its meaning. It may seem more general in this way: In the figure let x represent mass, and O1 a unit of mass; also let y represent temperature; then, if a suitable unit of temperature has been chosen, the area O1$b\tau$ will represent the heat energy contained in the unit mass at the temperature τ. Now we may cut this energy into n equal parts by means of equidistant vertical lines, and these lines will cut the mass also into n equal parts; in this case it requires no scientific imagination to see that the effect of the heat belonging to any one of the increments of mass must be the same as that belonging to any other, and that the heat of one increment is similar to that of another though not quite similarly circumstanced, because the increments of mass have different positions in space.

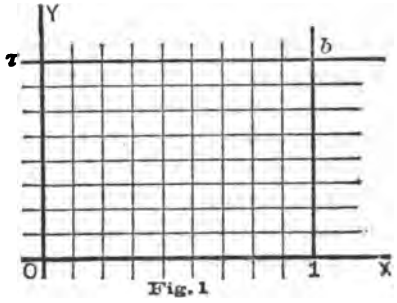


Fig. 1

Such a method of dividing the total actual heat is altogether too simple for the use to be made of it, and no such statement can pass for a law of thermodynamics; it is simply the law of homogeneousness. If the mass of a homogeneous body be divided into n equal parts, then the effects of these parts are the same in making up the total weight, value, density, etc., etc., of the body.

Rankine leads up to his statement in an unfortunate way, perhaps, in emphasizing the fact that every particle is equally hot without telling why; of course every particle must be so, or we could not speak of the body as having a temperature τ, and the right line τb in the figure would disappear; this would interfere with the argument, which depends essentially upon our dividing a temperature τ into equal parts.

Rankine intends no such vertical subdivision; he says, in fact, "Let unity of weight," and we may take a differential unit, and so put such a division out of the question. The division intended was

by horizontal lines, and this makes the first statement of the law identical with the second, only in the one he says "total actual heat," and in the other "temperature." He commences by saying "heat," because heat is energy and is the real thing he refers to, and he changes to "temperature," because that is the practical way of measuring the amount of this energy, being proportional to it.

I believe, then, that this is the one and only second law, and it follows that because our agent is a quantity of energy, which resides only in mass, and because different substances do not differ in mass — that being a common or fundamental property of all substances— therefore, the particular working substance used has no effect upon the result.

To further illustrate the division into equal parts, which Rankine intends, let us consider the pressure produced by a mass under the action of gravity.

The rectangle O1$b\tau$ will represent this pressure for a unit of mass if we lay off the acceleration of gravity on O Y so that $\tau = g$. We shall have the same two possible divisions as before; that by vertical lines will correspond with the fact that each equal element of mass contributes its own equal share of the pressure, while for the horizontal division we must regard the force of gravity as made up of equal increments, each of which takes equal part in producing it. Now, it is a matter of no consequence whether we say "divide the acceleration g into n equal parts" or, "divide the force gm;" in the one case each increment will be represented by a portion of the line O Y and will correspond to an increment of temperature, in the other each will be represented by a horizontal band

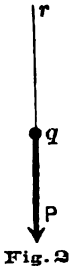


Fig. 2

of the area O1$b\tau$ and will correspond to an increment of total actual heat. There may be more difficulty in conceiving of a division of the temperature or of the acceleration into equal parts,

than of a division of the energy or of the force, or weight, but this difficulty lies in conceiving of either acceleration or temperature as a *quantity* and not in the division of that quantity; both, however, must be so conceived of before a mathematical or other exact treatment of them can be made. If we conceive of a force or weight, P, as applied at a particular point (let it be attached, say, to the geometrical line *rq*) without our knowing the acceleration of gravity or the mass, but only their product P, then, while both divisions of P into equal parts are still possible, that into horizontal bands would seem to be the most natural; any variation in P would usually, I think, be considered as resulting from a change in the acceleration, in which change each equal part will have the same effect in producing the pressure P, and they will all be similar and similarly circumstanced.

If the camel's back does break, it is the first hair as much as the last that does it—this illustration, however, corresponds to the vertical subdivision, and we must suppose the fully-loaded camel to move through space in such a direction that gravity shall continually increase, in which case it will be the first increment of g as much as the last, which will tend to break his back.

Let us look again at the efficiency formula, which flows directly from Rankine's law in a simple and evident manner. Our infinite-cylinder engine needs no such formula, for it works *at* a temperature τ and not between two temperatures τ and τ'; it also transforms permanently all the heat into work. Mechanical considerations, however, require us to forego infinite cylinders and to build engines that run in cycles, and for these this formula is needed. Every engine running in a cycle is a double engine and consists of an engine proper and a compressor. When the piston has risen as far as the practical height of the cylinder admits, during which rise it has converted all the heat used into work, some method must be taken to repeat the process with the same engine. The engine is therefore used as a compressor for re-compressing the gas, during which operation all the work done on the gas is transformed into heat, and we have only to cool it before compression by adiabatic expansion or a regenerator, in order to get it back again to its original density and have left a margin of heat permanently transformed into work, in accordance with the efficiency formula.

It should be remarked that no special reference has been made in this address to anything but a perfect-gas engine because the

theory of the action of such an ideal gas should be perfectly clear before the more complicated action of real substances, especially liquids and solids, is considered; Rankine's law, however, covers all such cases, and his definitions and formulæ are framed to include them.

Many other points have necessarily been left untouched, but if I have made clearer how heat, and therefore temperature, may be supposed to consist of a number of equal parts, and how these parts cannot differ in their situation or action, and convinced you that Rankine's is the real and only second law of thermodynamics, my object will have been accomplished.

PAPERS READ.

STRENGTH OF STAY-BOLTS IN BOILERS. By L. S. RANDOLPH, Susquehanna, Pa.

[ABSTRACT.]

A LARGE number of stay-bolts were found to be broken in some locomotive boilers which had been in service about six years. The fracture was invariably close to the surface of the shell of the boiler which was one-eighth of an inch thicker than the firebox sheets.

The fracture was square across, following the bottom of the thread and seemed to start there.

With a difference of 200° in the temperature of the firebox sheet and shell, an expansion of about one-eighth of an inch, in a firebox ten feet long, would occur. To test the effect of this motion a stay-bolt, fitted up just as in a boiler, was secured in a shaping machine and one end given a vibratory motion of one-eighth of an inch.

Common iron stood from 1,000 to 3,000 revolutions, ordinary stay-bolts from 3,000 to 6,000, best stay-bolt iron from 6,000 to 12,000. With one-sixteenth of an inch motion, common iron stood 30,000 vibrations without sign of fracture.

The writer concludes from the above experiments that any further increase in length of firebox will have to be met either by an increase in breadth of water spac or some other device by which the bending of the bolt may be lessened.

The fractured end of the stay-bolts broken upon the shaping machine was very curious; the neutral axis being marked by a dark band about one-sixteenth of an inch broad in a seven-eighths of an inch bolt, the metal on either side being granular to crystalline.

From the above experiments, the following test for stay-bolt iron was devised: one end of the rod to be tested was fastened in a vise and a piece of pipe slipped over the other end to within six inches of the vise. The iron was then bent until the portion in the pipe was at right angles to that in the vise and then bent back to its original position, the bending being repeated until the metal broke.

THE USE AND VALUE OF ACCURATE STANDARDS FOR SURVEYORS' CHAINS. By STEPHEN S. HAIGHT, C. E., West Farms, New York, N. Y.

[ABSTRACT.]

THIS paper was devoted to a description of the standard of measurement used by the Department of Public Parks of New York City, and the method of adjusting steel measuring tapes to this standard.

This standard consists of two stone monuments covered by metal plates, and set in the earth beneath a building, at a distance of fifty feet between points on the plates. Openings in the floor of the building afford facilities for transmitting the standard by means of plumb bobs to the chain or tape, suspended as when used above the floor.

The tape is provided with a level and spring balance and is intended to be used at a tension of eight pounds; a set screw and thermometer at one end serve to adjust the length of the tape to the temperature at time of using. Distances of less than twenty feet are measured by means of a graduated steel tape.

THE LATHE AS AN INSTRUMENT OF PRECISION. By Prof. J. BURKITT WEBB, Stevens Institute of Technology, Hoboken, N. J.

[ABSTRACT.]

THE lathe, taken for itself or as the representative machine tool, may be regarded in two entirely different lights, either as a more or less rough machine for the removal of material, or as an instrument of precision. In the development of man as a mechanician, we regard him as at first a more or less brute animal possessed of great bodily strength and engaged in the exertion of that strength in various rude, inaccurate and also uneconomical ways. The civilized mechanician of to-day is, however, an intellectual being who guides the forces of nature to do his work, and aims at a degree of accuracy and precision in the same, impossible in former years. As the man is so are his tools; the lathe, which was formerly chiefly employed in its brute capacity, has now (owing to the efforts of astronomers as well as mechani-

cians) attained the rank of an instrument of precision. The object is no longer simply to remove material, but it must be done with a high degree of accuracy.

Regarding the lathe as such, we venture the following proposition:

All good lathes should be tested as instruments of precision, and by much the same methods as are employed with other instruments of precision, and the degree of accuracy should be either guaranteed or exhibited to the purchaser by means of suitable instruments.

But one illustration will be given of the numerous applications of the above: The axis of the spindle of a lathe should be parallel to the ways. This may be tested essentially as follows: Upon the face plate fasten a small disc of metal or other substance and scribe upon it a circle by fastening the scribe permanently to the tool post and revolving the spindle by hand. Then fasten to the face plate a frame consisting of three or four stiff wooden rods of equal length, meeting in a vertex as far from the face plate as the length of the ways makes suitable, and having their other ends attached to the face plate at points equidistant on its circumference; the vertex of this frame will then be in the axis of the spindle produced, and it should be faced off parallel to the face plate. Now remove the disc from the latter and mount it up on the end thus faced off, so as to have the scribed circle run nearly true, and run the carriage up to it, so as to scribe another circle upon it. If the spindle is in line with the ways the two circles will be of the same size, but if there be a difference of size it may be seen, and can be measured under the microscope; the difference in radius will be the amount the spindle is out in the distance between the two positions of the disc and in the direction of the radius joining the scribe with the axis. This test should therefore be made twice; once with the scribe on the same level, and once with it directly below the axis. By a variation of this method, after a preliminary scribing of the circle upon the disc, the microscope may be attached directly to the carriage and measurements made of the circle in the two positions, leading to the same result without scribing a second circle.

ECONOMY OF ACCURATE STANDARDS. By Prof. J. BURKITT WEBB, Stevens Institute of Technology, Hoboken, N. J.

[ABSTRACT.]

THE economy of accurate standards in the machine shop will be apparent to all who sufficiently examine the subject; let us look at it in connection with commercial bolts and nuts, machine screws, etc.

As long as bolts and nuts are made in the same shop, there may be no special difficulty in securing serviceable fits, but when screws, nuts, dies and taps are manufactured by the quantity and put upon the market by a variety of firms it becomes a question of making such allowances in the dimensions as shall insure the easy entrance of a screw into a nut or hole tapped to the corresponding nominal size and thread. In other words all screws must be made too small and all nuts too large, by a quantity covering the errors incident to rapid and cheap production. The size of these errors depends largely upon the accuracy of the standard rules, screws and gauges employed, and it becomes a question of comparing the cost of standards of the highest accuracy with the increased value of the screws and nuts resulting from their use. Great improvements have been made in this respect, but an examination, especially of the machine screws and taps in the market, will convince any one that more is needed.

A screw is reduced in value in many ways by being poorly fitted to its nut:

I. The reduction in diameter necessary to insure a fit weakens the bolt.

II. This same reduction may seriously reduce the effective depth of the thread and therefore necessitate a coarser pitch, thus further weakening the bolt. In fact, as experiment will show, the strength of small bolts and machine screws might be *largely increased* by using *finer pitches*.

III. Reduction of effective depth of thread is a loss of wearing surface, which is important where the bolt is much used or sustains a heavy pressure.

IV. It leaves the threads partly open, so that grit and water may enter and cause wear and rust.

So much for the reduction in diameter, but further:

V. A slight difference in pitch caused by making male and female threads in different lathes, or even in the same lathe with a leading screw or multiplying gearing of poor construction, will cause the contact between the threads to occur at one end or other of the nut, while for the remaining distance there is no contact. With long nuts this may be a serious difficulty; when the nut is short, however, the metal may wear or yield until a sufficient contact is obtained.

VI. Errors in the angle and, generally, in the shape of the thread, also reduce the wearing surface and may cause undue pressure or even a jamming together of the threads.

An improvement in small bolts and machine screws is imperatively needed; they should in general be cut to finer pitches and better fits.

Experiments upon the coëfficient of efflux of automatic sprinklers. By C. J. H. Woodbury, Boston, Mass.

[ABSTRACT.]

The discharge from seventeen of the principal forms of automatic sprinklers was carefully measured at pressures varying from 3 to 140 pounds to the square inch, for the purpose of determining the proper sizes of pipes necessary to supply such apparatus in the protection of buildings against fire.

The results conformed to this equation:

$$Q = 5.075\ \varphi\ a\ \sqrt{p}.$$

Q = discharge in cubic feet per minute.

φ = coëfficient of efflux.

a = area of orifice of sprinklers in square inches.

p = water pressure in pounds per square inch.

The coëfficient of efflux φ was found to be a constant quantity throughout the range of the experiments.

These constants and measurements were as follows for the sprinklers tested:

Kind of Sprinkler.	Area of orifice. sq. in. a.	Coëfficient of efflux. φ.	Coëfficient discharge 5.075 a φ.
Parmelee,	.1760	.5356	.4784
Grinnell,	.1963	.5576	.5555
Brown's Standard,	.2517	.4810	.6144
Brown's Sensitive,	.2945	.4616	.6899
Walworth,	.1963	.7692	.7663
Bishop's Upright,	.3550	.4088	.7365
Bishop's Spring Deflector,	.2769	.6968	.9722
Bishop's Valve Deflector,	.2485	.7531	.9498
Burritt's Rose,	.2580	.4791	.6273
Burritt's Open Base,	.9780	.1717	.8531
Burritt's Sensitive,	.1503	.8295	.6327
Harris deflector,	.1963	.7325	.7298
Harris closed,	.1428	.7130	.5167
Whiting,	.1840	.5777	.5395
Heath,	.2200	.5224	.5832
Kane,	.1665	.7297	.6166
Ruthenburg,	.3068	.4805	.7482

These results were applied to a determination of the sizes of pipes for a sprinkler system dependent on a tank of water for the first supply until the fire pumps could be put in operation, giving a discharge of one cubic foot per minute from each sprinkler and allowing throughout the system a loss of head, as near as practicable, of thirty per cent.

Diam. of Pipe.	No. of Sprinklers.	Loss by Friction. Feet.
$\frac{3}{4}$	1	1.31
1	3	2.64
$1\frac{1}{4}$	6	2.34
$1\frac{1}{2}$	10	2.7
2	18	2.8
$2\frac{1}{2}$	28	2.6
3	46	2.9
$3\frac{1}{2}$	78	3.1
4	115	4.1

ELECTRIC LIGHT TESTS. By FRANK C. WAGNER, Ann Arbor, Mich.

THE following tests were made with a view to determining the actual economy of the two electric light plants examined. The work includes tests of the boiler, engine and dynamo of each plant. Great care was taken to make the measurements accurate. The steam gauges, thermometers and barometer were compared with standard instruments belonging to the University of Michigan, and their readings corrected. The springs of the Thompson indicator used were tested by a device of Prof. M. E. Cooley's.[1]

The electric current was usually measured by a dynamometer of the Siemen's pattern constructed by the writer. The constant of this instrument was carefully determined by comparison with a galvanometer which had previously been standardized by means of silver and water voltameters. In one instance a Deprez amperemeter was used. To measure electromotive force, the high resistance coil of a Bradley galvanometer was used in circuit with an external resistance of 22600 ohms. To determine the constant of the Bradley at the time and place of making the observations, the following method was used. A single-fluid, bichromate battery cell was taken along, and at intervals during the progress of the test, the deflections produced by it in the galvanometer with certain known resistances in circuit were noted. The instruments were then taken to the physical laboratory of the University of Michigan, and the deflections through the same resistances with the same cell were again noted. The inverse ratio of the tangents of the deflections in the two cases gives the ratio of the constants. At the same time the true constant of the instrument was determined by means of a freshly set up Daniell of known electromotive force.

The dynamo of the Edison plant was a 200-light machine belted directly to the driving pulley of the engine. There were 165 lamps on the circuit, which were turned off and on at the convenience of the persons using them. The current was divided between two main circuits; one, formed by a single 00 wire, supplying the lights which were nearest to the station, the other, formed by two 00 wires, supplying the more remote lights. Two different boilers of the horizontal tubular type were in use at different times.

[1] For a description of this device, see page 165 of these Proceedings.

The engine was a horizontal engine of an old type with a ball governor and throttle valve, making about 210 revolutions per minute.

Priming tests were made, showing that the steam contained on an average 5.6 per cent of moisture. The friction of the engine was determined by the use of a Prony brake, and found to be 12.2 per cent. A complete test was made of each boiler with the engine, the usual precautions being taken to ensure accuracy. The following are the mean results of the two trials:—

Pounds of water evaporated per pound of coal under actual conditions, ...	6.417
Equivalent evaporation from and at 212°, . .	7.301
Pounds of water per. I. H. P. per hr., . . .	79.05
" " " " net H. P. " " . . .	90.1
" " coal " I. H. P. " " . . .	12.36
" " " " net H. P. " " . . .	13.83

After a number of trials to determine the method to be employed, and to discover and eliminate sources of error, the electrical test was made as follows. A coil of 00 copper wire containing about 195 ft. was spread out on the floor so that the successive spires did not touch one another. The ends of the coil were connected to the posts of the dynamo between which the switch is situated, so that when the switch was out the current passed through this coil. Near the ends of the coil were soldered two leads which ran to the terminals of the electrodynamometer. Thus the coil of 00 wire formed a shunt for the dynamometer, enabling it to be reversed or cut out by means of a commutator without affecting the main circuit. The resistance of the electrodynamometer, commutator, and connecting wires, connected up as when in use, was determined accurately by the use of Wheatstone's Bridge.. The distance between the leads along the coil was found and the resistance of this portion of the wire computed. Knowing these two resistances, the value of the shunt is easily found. The variation of the contact resistance of the commutator was the chief source of error here. The greatest observed variation from the mean in any double throw of the commutator would produce a variation of five per cent in the shunt multiplier.

For the measurement of electromotive force, connections were made with the line wires just where they left the dynamo. The connecting wires were led off into another room at a distance of

about 40 ft. from the dynamo, where all the observations for the measurement of electromotive force were made. Readings of the dynamometer and galvanometer were taken every fifteen minutes, as were also the steam pressure, number of revolutions and indicator cards. The following are the results of the test. By *electrical efficiency* is meant the efficiency of the dynamo in converting mechanical into electrical work. It includes the friction of the armature bearings and of the belt transmitting the power from the driving pulley of the engine. By *commercial efficiency* is meant the ratio of the *available* electrical work to the mechanical work given off by the driving pulley of the engine. It includes both the energy expended in the lamps and that wasted in heating the conductors external to the dynamo.

Mean number of lamps in actual use,	135.	
Mean total electromotive force	101.1	volts.
Mean electromotive force at poles of dynamo,	95.93	volts.
Mean total current,	90.77	ampères.
Mean current in electromagnets,	2.31	ampères.
Mean electrical efficiency of the dynamo,	84.21	per cent.
Mean commercial efficiency of the dynamo,	78.42	per cent.
Pounds of coal per net electrical H. P. per hr.,	17.63	
Number of lamps per net electrical H. P.,	11.86	
Number of lamps per indicated horse power,	8.17	

In the Van Depoele electric light plant, two dynamos were used, the smaller one generating the current for the field magnets of the larger. Thirty-three arc lights were included in the circuit of the larger dynamo. These were kept running steadily through most of the evening, a few being turned off toward the close. The line was formed by about 1.3 miles of No. 7 B. W. G. copper wire. The dynamos were belted directly to the two driving pulleys of the engine. The boiler was of the ordinary horizontal tubular type. The engine was a new Ball, automatic cut-off, high speed engine. By means of priming tests the steam was found to contain 1.01 per cent of moisture. The friction of the engine was found to be, for the load used, 17.1 per cent. A complete boiler and engine test gave the following results:—

Pounds of water evaporated per lb. of coal under actual conditions,	5.898
Equivalent evaporation from and at 212°,	6.287
Pounds of water per I. H. P. per hr.,	37.9
" " " " net H. P. " "	45.75
" " coal " I. H. P. " "	6.43
" " " " net H. P. " "	7.75

Two electrical tests were made of this dynamo. The manner of making the test was as follows. The entire main current was sent through the electrodynamometer, which could be reversed or switched out of circuit at will. The current of the exciting dynamo was measured by the ampère meter. To find the mean resistance of a lamp the electromotive force of two lamps was measured at the same time that the current measurements were made. By Ohm's law we have the resistance equal to E C. In the second test complete measurements were made. In the first test the measurements of electromotive force, and of the current in the exciting circuit were omitted. In the calculation the resistance of the lamps and the energy of the exciting circuit are assumed to be the same as in the second test. The energy of the exciting circuit was calculated by the formula, $W = C^2 R$. For the main circuit the mean resistance of one lamp, found to be 3.055 ohms, was multiplied by the number of lamps (33 in the first test and 32 in the second); and to this was added the resistance of the armature and line wire. Several attempts were made to measure the resistance of the line wire directly; but it was found that the line circuit included a resistance which varied with the electromotive force used. The resistance was, therefore, calculated from the length and diameter of the wire. It is well to note that if the resistance were greater than it was assumed to be (it cannot be less), both the electrical and commercial efficiencies would be *increased*. The following are the results of the two tests. The electrical and commercial efficiencies were calculated in the same way as in the Edison test.

First Test.

Mean total electromotive force (calculated),	1290 volts.
Mean current in main circuit,	11.88 ampères.
Mean electrical efficiency of the dynamo,	91.67 per cent.
Mean commercial efficiency of the dynamo,	80.29 per cent.

Second Test.

Mean total electromotive force (calculated),	1169 volts.
Mean current in main circuit, . . .	11.08 ampères.
Mean current in exciting circuit, . .	7.94 ampères.
Mean no. of revolutions of larger dynamo, .	818.
Mean no. of revolutions of smaller dynamo, .	1436.
Mean electrical energy in exciting circuit, .	1.67 H. P.
Mean total electrical energy, . . .	19.04 H. P.
Mean electrical efficiency of the dynamo, .	93.94 per cent.
Mean commercial efficiency of the dynamo, .	81.11 per cent.
Pounds of coal per net electrical H. P. per hr.,	9.56
Number of lamps per net electrical H. P.,	1.95
Number of lamps per indicated horse power,	1.31

I desire to express my obligations in making this test to Profs. M. E. Cooley and C. K. Wead for advice and assistance, to Prof. M. E. Cooley and Messrs. G. M. Ames, E. D. Clary, and A. E. Kastl for making the boiler and engine tests, and to Mr. C. H. Lane for valuable aid in making the electrical test. I am also under obligations to Mr. C. B. Davison, engineer in charge of the Edison station, and to Messrs. Stevens and Bell of the Van Depoele station for many favors shown during the progress of the test.

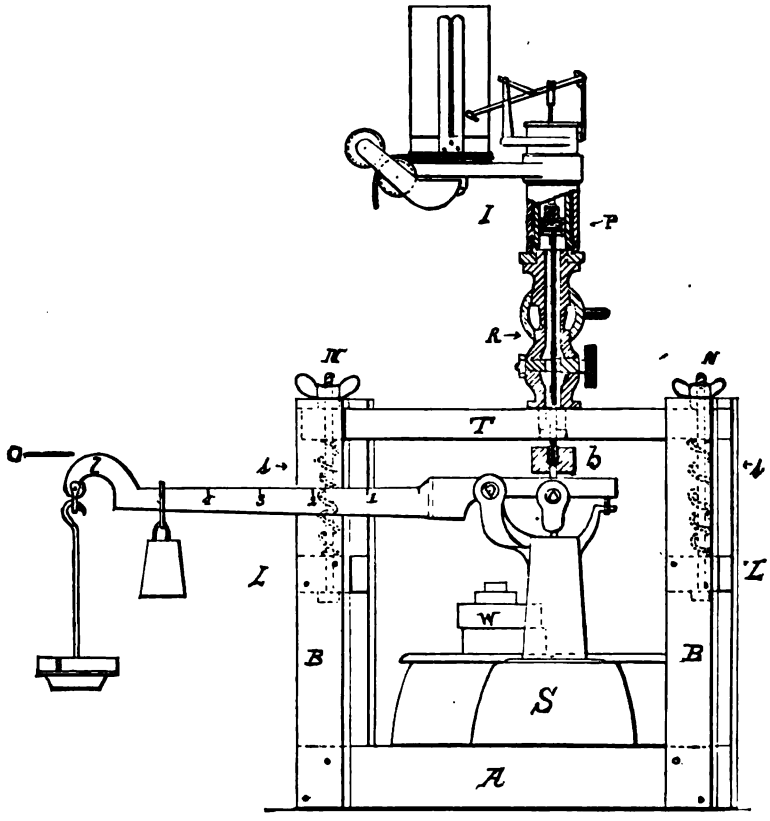
A NEW DEVICE FOR TESTING INDICATOR SPRINGS. By Prof. M. E. COOLEY, University of Michigan, Ann Arbor, Mich.

[ABSTRACT.]

THE simple piece of apparatus illustrated was devised by the author, and used in the Mechanical Laboratory of the University of Michigan the past year with great satisfaction. It is easily made, conveniently applied, accurate, and applicable to all kinds of steam indicators in the position and under the circumstances of actual use.

The frame *A B* has a sliding top, *T*, guided by corner posts, held up by springs, *s*, and raised and lowered by the nuts *N*. The indicator cock screws into a hole in *T*. An ordinary grocery scale, previously tested, is placed with the point *b*, directly under the hole in *T*. A rod, *R*, with rounded ends, rests with one end on *b* held loosely in place by a block of wood with a hole in it; the

other end of the rod bears against a piece of wood, with a concave depression in it, in the hollow of the indicator piston. The scale is balanced with the rod in position by means of weights on the platform. Then the indicator with the spring to be tested is screwed in place, care being taken to adjust the rod in a central position. A card is placed on the drum, the atmospheric line



drawn, and the weights for any desired pressure are then placed on the beam, the nuts, *N*, being screwed down until the end of the beam comes to a zero line previously established. If the pencil is sharp the scale can be read quite accurately.

The spring may also be tested hot by playing a jet of steam on the jacket of the indicator, or by using a liquid of high boiling point.

CYLINDER CONDENSATION IN STEAM ENGINES. By Prof. ROBERT H. THURSTON, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

THE author presented the results of a series of experiments made, under his direction, to determine the extent of the loss occurring in steam-engines by the action known as "cylinder-condensation," and the laws determining the method of variation of that waste. In a paper presented to the New York Academy of Sciences several years before, it had been stated that the nature of the function which measures the magnitude of this loss is "determined by the area of cylinder-surface, time of exposure, variation of temperature of surface, and quantity and character of the working steam." The author had been compelled to assume the form of this function in the construction of a theory of efficiency of actual engines, and after studying such experiments as had been described up to that time, had concluded that it would be substantially correct to take the quantity of steam condensed as varying as the square root of the ratio of expansion adopted in the engine. It was remarked that "a comparison of the quantities of steam demanded to supply an engine thermodynamically perfect with the actual quantities required by even the best of engines exhibits so wide a difference that it becomes obvious that the determination of the efficiency of the engine, and the solution of the questions involving those of expenditure of heat, are not problems in thermodynamics, simply. The mathematical theory of the steam-engine is not yet in so satisfactory a state—and cannot be until the correct theory of this transfer of waste heat can be introduced into it—that the engineer can use it in every-day office-work with much confidence, unless checked by direct experiment."

It had been the intention of the author to determine experimentally, if possible, the laws governing the amount, and the variation, of cylinder condensation in steam-engines, the speed of piston, the area of surfaces exposed to the steam, the ratio of expansion, and the pressure and temperatures of the steam varying in the manner, and to the extent, usual in practice. Such an opportunity as had been looked for, for several years previously, was finally offered, when Messrs. Gately and Kletzsch were permitted to undertake such an investigation upon a Harris-Corliss engine of 250

horse-power, at the works of the Newton Packing and Belting Co. Before this date, some work had been done, notably by Chief Engineer Isherwood, U. S. N., in the United States, and by Messrs. D. K. Clark in Great Britain and Hirn in France; but no completely systematic examination of the methods of variation of all the most important variable elements had been made or attempted, so far as was known.

Messrs. Gately and Kletzsch undertook such a systematic investigation, making all working conditions constant, for each trial, then varying each one of the governing conditions, singly, through a wide range of ordinary working conditions until, at the end of the research, the method of variation of loss had been observed for each variable independently.

The power of the engine was fixed, and its speed controlled so far as independent of the governor, by a "Prony Brake" which was designed by the experimenters especially for their work, and calculated to work safely up to above 500 horse-power. The indicated power of the engine was carefully determined, at short intervals, by the use of steam-engine indicators, which were carefully tested, and proven to be correct. The character of the steam was ascertained by means of a calorimeter, and the quantity of steam, and of water, used was measured by meters, and by a weir placed at the delivery side of the air-pumps.

The work was very carefully done by Messrs. Gately and Kletzsch, assisted by Passed Assistant Engineer C. A. Carr, U. S. N., and others. The investigation was carefully planned by the author and the investigators, the observations very exactly made, and recorded, and the results worked up with the utmost patience and skill.

The report, as finally presented to the author, was illustrated by curves exhibiting the law of variation of loss, as deduced by the gentlemen in charge of the work, and tabulated by them. It was found that the assumption made, as above stated, in regard to the law of variation with varying ratio of expansion, was corroborated; while some discrepancies were observed with the results apparently reached, in some cases, by earlier investigators.

The most important result of this work was the confirmation of the law already established relating to the variation with varying ratios of expansion, the most common of the variables, in ordinary

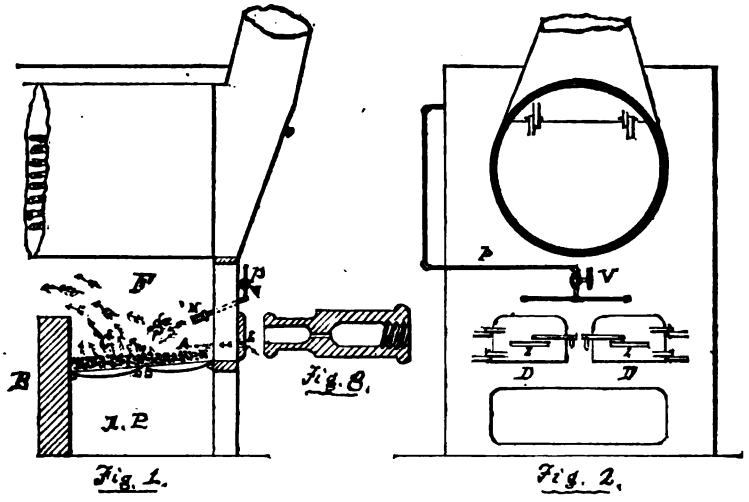
practice. The research was presented as simply a first attempt at systematic and complete investigation of this important problem, and it was stated that further work in this direction is very desirable. The whole of the report of Messrs. Gately and Kletzsch to Dr. Thurston is published in the Journal of the Franklin Institute for October, 1885, and succeeding numbers, and in the London Engineer of November.

THE DAVISON SMOKE BURNER. By Prof. M. E. COOLEY, University of Michigan, Ann Arbor, Mich.

[ABSTRACT.]

THE sketch illustrates a simple, effective and efficient smoke burning device. It is inexpensive, easily applied to any boiler furnace, and requires but little attention.

L is a slot, about 1 in. by 10 in., cut through each furnace door through which the air passes in a broad thin stream. P is a $\frac{3}{8}$ in.



steam pipe branching and entering as a $\frac{1}{4}$ in. pipe over each furnace door, having nozzles N, as shown in Fig. 3, placed so as to direct the stream past the middle of the furnace. The fuel is fired in small quantities into the back end of the furnace, a bed of in-

candescent fuel being kept in front. The air entering at L becomes highly heated in sweeping over the incandescent fuel at A, and is thoroughly mixed by the steam jets with the products of imperfect combustion rising from the bed of fuel. Combustion ensues with a roaring noise and an almost total absence of smoke. The evaporative power and efficiency of the boiler are both considerably increased.

A PRONY BRAKE FOR GOVERNING POWERFUL STEAM ENGINES. By Dr. ROBERT H. THURSTON, Cornell University, Ithaca, N. Y.

GENERAL DISCUSSION OF THE BEST METHOD OF TEACHING MECHANICAL ENGINEERING.

ON A UNIVERSAL FORM OF PRESSURE MOTOR. By Prof. DAVID P. TODD, Lawrence Observatory, Amherst, Mass.

DEEP WATER AT GALVESTON, TEXAS, AND HOW TO REACH IT. By Dr. ALEXANDER HOGG, Fort Worth, Texas.

THE INTER-OCEANIC PROBLEM, AND ITS SCIENTIFIC SOLUTION. By ELMER L. CORTHELL, New York, N. Y.

[This paper, by special action of the Standing Committee, was given at a General Session of the Association on Friday evening. It has since been published as an 8vo pamphlet with map and illustrations of the proposed Tehauntepec ship railway. This pamphlet can be had by addressing the author at 34 Nassau St., New York.—EDITOR.]

SECTION E.

GEOLOGY AND GEOGRAPHY.

ADDRESS

OF

PROFESSOR EDWARD ORTON,

VICE PRESIDENT, SECTION E.

FELLOW MEMBERS OF THE SECTION OF GEOLOGY AND GEOGRAPHY:

WE have again assembled in our annual council, to renew and extend our acquaintance with each other, to maintain and strengthen the *esprit du corps* which ought to characterize the workers in a common field, to share with each other the new facts and new conclusions that we have reached by the labors of the last year, *mente et malleo*, and especially to aid each other in securing larger and more symmetrical views of the truths we hold, by fraternal discussion, criticism and correction.

The students of no other branch of science have greater need of such association, for our field is so wide that those who occupy its different sides can easily lose sight of each other. In other words, the methods of investigation and research employed in the several sections of geological science are so diverse that it is quite possible for those who work in one to fail in due appreciation of and due respect for all the rest.

But the putting asunder of things which belong together is always to be deplored. It will be an evil day for geology when, by any confusion of tongues, the utterances of its various builders become unintelligible to one another.

The most encyclopedical of the sciences, geology still demands of its students a wide range of knowledge and interest. Its most substantial progress will be due in the future as it has been in the past, not to the level and clinometer alone, not alone to the sagacious interpretations of the relics of life, not alone to microscopic section or to chemical analysis, but to all combined, and the employment of these various instruments and agencies of research is still the condition of the largest service and success.

To review the record of the last year and gather up its most significant advances would be appropriate to the occasion, but

various limitations forbid me to undertake such a task in any formal way.

Before entering, however, upon the discussion of the subject which I wish to present to you, I beg leave to call your attention to a few facts, chiefly gathered from the recent labors of American geologists, that seem to me of special interest and that would properly belong in such a list as I have named. I will also point out, in like cursory manner, some of the special directions and subjects in which American geology seems to me to be showing the most activity and progress at the present time.

1. The history of the vertebrate life of the globe, as far as it is now written, indisputably owes some of its most interesting and important chapters to American geology, but up to the last year we were still obliged to recognize the Ludlow rocks of Great Britain as the depositaries of its earliest known forms. But the recent fortunate discovery and the clear and sagacious interpretation of vertebrate fossils of the Pteraspidian type of fishes in the Onondaga Group of central Pennsylvania, by our associate, Professor E. W. Claypole, have granted us an equal date, at least, with the *Scaphaspis* of the Lower Ludlow of Great Britain, and a fair argument can be made as to the somewhat greater antiquity of the Pennsylvania forms. This argument it is not necessary to press, for it loses its point and interest in the light of Prof. Claypole's subsequent discovery of well-marked scales and spines of fishes in the Iron Sandstone of the *Middle Clinton Group* of central Pennsylvania. *Onchus Clintoni* of Claypole comes from a horizon that is much farther below the Ludlow beds than they are below the next stratum in ascending order in which vertebrate remains have hitherto been found, viz., the Lower Devonian Limestones, and it must enjoy the distinction, at least for a little time, of being recorded as the earliest representative of the vertebrate life of the globe, and earliest by a long remove from every known competitor.

But the "earliest vertebrate" always sits on a precarious throne. At any moment the title is liable to lapse. To see its horizon suddenly descend several thousand feet in the scale scarcely awakens our surprise. The abrupt appearance, the great numbers and the comparatively high organization of the earliest American fishes heretofore known, all demand a long antecedent history, and it is therefore no unwelcome labor to erase the old boundaries and

to draw the new ones so as to gain protracted ages for the unfolding and development of the type.

2. Another fact in the history of vertebrate life, acquired during the past year, deserves special mention here. Mr. Samuel Garman has recently published in a bulletin of the Museum of Comparative Zoology of Harvard College, a description of a living shark that proves to be a *Cladodont* and, according to his interpretations, so nearly allied to the genus *Cladodus* of Carboniferous time that it might with little violence be referred thereto. According to present knowledge, the family of *Cladodonts* originated in the Middle Devonian, and the genus *Cladodus*, as we have hitherto been obliged to hold, became extinct in the same age that gave it birth, but the chance catch of a Japanese fisherman gives us an unmistakable *Cladodont* if not a true *Cladodus* to-day, and in it, we find "the oldest living type of vertebrates," *Ceratodus* being thus displaced from the prominence which it has so long enjoyed. The gap is far wider than any that has been heretofore bridged, and the lessons derived from the discovery are correspondingly important. We are taught to look with keener interest and larger expectation upon what "the dark, unfathomed caves of ocean bear." The fragmentary character of the record of life, which we all acknowledge, is set before us in more vivid light, and we are warned anew against all dogmatism in dealing with it.

3. The discovery during the last year of fossil scorpions in three quite widely separated portions of the world, at horizons approximately identical and at the same time, vastly lower than any in which they had been found hitherto, is a fact of much geological interest and significance. The first of these forms was reported from Swedish territory, in November, 1884. The age of the formation from which the fossil was derived is clearly Upper Silurian. This announcement was immediately followed by the report of a like discovery in Upper Silurian rocks of Scotland, and now, our associate, Prof. R. P. Whitfield, has obtained from Lower Helderberg beds of Oneida County, New York, classic ground for this formation, a well-marked congener of the Swedish specimen. It is surprising that these three specimens, gathered as they are from widely-separated but well-worked fields, should come to light within the compass of a single year. They effect an immense extension of the history of the tribe to which they belong, but each of them still falls short of the title of the "earliest known

land-animal." That distinction is, for the present, held by the representative of an allied division. From well-characterized strata of *Middle* Silurian age in Central France Mr. Scudder has described, during the past year, the fragment of a cockroach's wing. It is a surprise to find *Blatta*, for the time being, at the head of the line of the inhabitants of the dry land.

4. Within the last year, our associate, C. D. Walcott, has published a description of two species of pulmoniferous mollusks from the lower portion of the Carboniferous rocks of Nevada. Both belong to the aquatic section of the pulmonifera and constitute the sole known representatives of that group in Paleozoic time. One of them is a true *Physa* and thus gives to this humble form a vast antiquity.

There have been previously described eight species of pulmonifera from the Paleozoic rocks of North America, all of them true land shells and the only representatives of the subclass thus far known to science from rocks of this age. It is interesting to find the aquatic section now coming into view, also from American rocks.

But leaving without further notice these very suggestive facts, the list of which might be easily and largely increased, let us barely glance in passing at some of the chief features in the advance of geological knowledge in this country at the present time.

In the first place, stratigraphical geology appears to me to be attaining a somewhat juster recognition than has hitherto prevailed. It has been made very clear by the labors of geologists in the field during the last few years that the work of the paleontologists is still too incomplete to allow any off-hand settlement of many of the questions that arise, by his determinations. Not only must stratigraphical work precede all paleontological conclusions, but it is becoming more apparent that these two branches of inquiry must never be divorced. They must advance into new fields, *pari passu*, so far as the minor divisions of the scale are concerned. The several papers of our associate, Prof. H. S. Williams, on the "recurrence of faunas" and the recent papers and reports of other geologists of the same tenor, are timely and valuable. There has been, in my judgment, an undue tendency to settle all questions as to the age and order of the several strata of any considerable series by the testimony of a few fossils. The fossils are the arbiters, it is true, if they have acquired their authority by sufficiently extended investigation, but it

is just here that the danger lies. They seem to me to have been sometimes so used as to discourage the persistent and continuous observation and comparison of sections by which and by which alone their final value is determined, and upon which all true progress as to geological order must depend. The problems of the Paleozoic rocks of eastern North America are mainly of the soluble sort, and the incongruous and irreconcilable sections that now disfigure our geological maps will disappear whenever enough connected field-work has been devoted to them, the field-work embracing both the stratigraphical and paleontological facts involved.

The work of unification is already going forward with most gratifying results, especially in the great series of strata that compose the eastern slope of the Mississippi basin. It has been found possible at last, under the United States Geological Survey, to treat the various elements in their undivided extent without regard to arbitrary boundaries and divisions. The service is an invaluable one to American geology.

In the second place, the growing use of the microscope in geology is to be noted as one of the directions in which progress is apparent and marked. There is scarcely a field of research in which the service of the thin section is not now acknowledged and invoked. It furnishes the only ultimate ground, if indeed it prove ultimate, for the division into genera and species of many Paleozoic corals and bryozoa, and, at the other extreme of the field, for example, it gives us the only approach to an explanation of the difference between flint clays and plastic clays. By it, most of the varied claimants to the early life of the globe must be tried and by it, as well, the minerals of the igneous and metamorphic rocks must be finally determined. Equally serviceable thus in the organic and inorganic fields, the microscopic section is rapidly growing to universal application in geological work.

Passing from the mention of these modes and directions of research, in which progress is obvious and pronounced, let us glance with equal brevity at two or three of the fields of American geology in which special activity now prevails.

I have already called your attention to the beginnings of vertebrate life on this continent as revealed in the fish-plates of the Middle Silurian of Pennsylvania, and I have reminded you that the oldest vertebrate in the American scale is the oldest vertebrate of the world, as well, so far as present knowledge goes,

but it is not in this fact that the chief interest of our vertebrate geology is found. It is in the later stages and higher forms of vertebrate life that American geology holds an easy and undisputed preëminence.

Along the eastern slope of the Rocky Mountains there are being disentombed, year by year, the remnants of great faunas of Cretaceous and Tertiary time that are quite without parallel in the history of geological science. While these faunas are remarkable for the great number and variety of the species and individuals contained, and also for the enormous size of some of their forms, it is in other directions that their highest interest lies. By their anomalous and altogether unexpected characters, by their strange combination and dissociation of peculiarities of structure, they throw a flood of light on the question of evolution and give us a key to the development of the existing creation that, before their discovery, it was too much to expect that we should ever possess. Here are birds with teeth, here are reptiles without them. Here are animals in which the characters of both birds and reptiles are so blended that it is hard to tell on which side of the line they belong, or whether there is any line. Here are horses with four toes and hogs that chew the cud. While the discoveries of the last year, so far as reported, do not vie in interest with those of many previous ones, still the work is going forward and new forms are constantly being brought into light. But of almost equal importance with the discoveries themselves is their formal publication, whereby they become the permanent property of science. The past year is made notable in this connection by the appearance of Marsh's monograph on the Dinocerata, in which are described thirty species under three genera, of a group of mammals but slightly known before, and whose various peculiarities of structure are full of significance and instruction as connected with the later mammalian life of the globe.

A second division of American geology in which special activity now prevails is that of the so-called Archæan rocks. The activity is "known and read of all men," but as to the progress to be reported, I dare not affirm, for the smoke of battle still covers the field and the clash of arms still fills the air.

Certain it is that in no previous year has there been so large and varied an amount of publication upon all of the problems involved as in the last. The list of authors includes many honored

names in our ranks, Whitney, Dana, Hunt, Hitchcock, Wadsworth, Irving, for example, and the topics discussed cover the whole range from the igneous fusion of the earth to the formation of a recent volcanic cone. The discussions are characterized by great ability, but the conclusions in regard to the fundamental facts of origin and classification of the great system of which they treat are wide apart and irreconcilable. Eozoon still maintains the struggle for existence, but with apparently lessening chances of survival. Let us hope that out of all this discord, which is not by any means confined to American geology, a consensus of opinion may soon emerge in regard to these universal foundations of the earth which shall deserve to be called orthodox. There will always be room in this field for heresies.

The third section of American geology that I will name as showing at the present time decided activity is that of glacial geology. The most recent of geological formations, the Drift, is still the most anomalous and perplexing. We have less experience and direct observation that can be brought to bear on its mode of formation than we have on oceanic deposits or even on the outflow of igneous vents. But, little by little, we seem to be coming into substantial accord in regard to the general sequence of the events that constituted the glacial period. The luminous and fruitful theories of Croll, like Darwinism in biology, are permeating all of our modern glacial literature.

The most important service that has been rendered in the American field is the recent mapping of the great moraine. Thanks to the United States Geological Survey, this work has now been carried through from the Atlantic border to Dakota, and in view of the facts which have thus been brought out, skepticism in regard to the former occupation of the northern portions of the continent by a sheet of land ice moving to the southward, would seem to be impossible to the candid mind.

It is coming to appear that the glacial record of the North American continent is, like the rest of its geological history, incomparably simpler and clearer than that of Europe, and both the order of events of the last ice age and the nature and mode of operation of the forces employed can be studied to better advantage here than elsewhere in the world. Our geologists are attacking these problems with courage and enthusiasm, and will certainly be able to give a good account of their labors. When we consider

how short a time has elapsed since the existence of a recent ice-period was first taught, we find ground for surprise that so much has been already accomplished, and yet it remains true that the history of the Drift is still to be written.

I will suspend at this point my desultory and informal review, and will turn now to the subject which I have selected for a brief discussion on this occasion.

I wish to bring before you a few facts in connection with the geology and chemistry of coal, the coal of the Carboniferous Period, that seem to me deserving of further and special consideration. They come to my mind as questions that have not been fully answered, as problems not satisfactorily solved; that is, they are not as fully answered or solved as possibly the nature of the case admits. In regard to them, more light seems fairly attainable, and it is therefore proper that attention should still be fixed upon them.

I will designate my subject Unfinished Problems relating to the Geology and Chemistry of Coal.

The title in this shape is, however, to some extent misleading. Literally interpreted, it covers too much ground, for what problems pertaining to coal or any other geological subject are finished? What questions are fully and finally answered? Every road in science leads to the end of the world. You can write the history of the vegetable kingdom from the beginning of time, in telling the story of the hyssop that grows on the wall.

Some of the questions that I raise are my own and difficulty in regard to them may be felt by but few. They may arise from the feebleness of imagination that is brought to the reading of the record, or from sheer lack of knowledge. Others are questions that have long been discussed and debated, and to the complete answers of which the resources of science may not yet be fully adequate. My hope is that some service can be rendered by stating and emphasizing the points involved.

1. For the last fifty years there has been no reasonable ground for doubt as to the real nature and ultimate source of coal. Coal is more or less metamorphosed vegetable structure, and consequently the materials composing it were, in the main, derived from the atmosphere, by the cells of growing plants under the agency of sunlight, at some earlier stage of the earth's history. These conclusions are questioned by no one who has a right to an opinion. Occasionally, it is true, some belated denizen of the seven-

teenth century still attacks the problem of the origin of coal in the *a priori* way and evolves a theory of its formation from his own consciousness. Such theories do not require refutation. Like the seed sown in stony places, they speedily wither because they have no root. Inventions and not discoveries, they are quite likely, in our day, at least, to go to their own place and to be buried with their inventors.

The formation of coal from vegetable growth I do not take to be an unsolved or unfinished problem.

2. Again, for the last fifty years, there has been no reasonable ground for doubt, or at least, ever-lessening reasonable ground for doubt that the vegetation which formed the coal grew where it is now found. It is not drifted vegetation but it was accumulated *in situ*, by the slow processes of plant growth. This position received powerful support from the famous paper of the late Sir William Logan which was read before the Geological Society of London in 1841. It was entitled "On the Character of the Beds of Clay lying immediately below the Coal Seams of South Wales." In it, Sir William announced the significant fact, which had long been known by the miners and used by them as a guide in their practical explorations and from whom he had received it, that all the coal seams of the South Wales field are underlain by beds of clay and that these beds always contain the well-known fossils, stigmaria. The statement of the fact we owe to him. Its modern significance escaped him for the time. The proof was forthwith furnished by Binney that the stigmaria are the roots or underground stems of lepidodendroid and sigillaria trees. At about the same time came the discovery, in a railway cutting near Manchester, of a number of sigillaria trees, standing unmistakably where they grew and immediately connected with a coal seam. These were the initial and epoch-marking facts in the history of the subject, but they have been repeated and supplemented and extended in every region of the world in which coal is mined, from that day to this, until they have become to the last degree familiar and commonplace. Supported by such an array of facts that seem to admit of but one interpretation, I should, for my own part, be disposed to place the doctrine that coal vegetation grew on land surfaces where we now find it, among the closed questions, the solved problems of geology, but remembering Grand-Eury's recently published erratic theory with its tornadoes and cataclysms, and Mohr's

elaborate reference of coal seams to sargasso seas, it may be necessary to leave this point a little longer among the unfinished problems of the coal. I should, however, give but little emphasis to the question involved in it. The rootlets of the stigmaria clays bind the coal seams fast to the surface of the land.

3. As we advance beyond this position and enquire as to the conditions and modes of growth of this land vegetation, we seem to find ourselves at once among the unsettled questions, the unfinished problems of coal. Most of the well-matured and more elaborate theories that have been advanced in recent times, however, agree still further, and in regard to a very important factor in the discussion. Almost all of them hold that this vegetation grew on lowlands and not only near the sea level but near the sea itself. The obvious facts of almost every section of Carboniferous rocks in which a seam of coal is included allow, indeed, no escape from this conclusion, but the particular modes of growth of these great sheets of vegetation are variously conceived and represented.

(a) Forests growing on swampy tracts, finally submerged and buried under sheets of sand or clay, the forest trees themselves, and chiefly their bark, constituting the bulk of the coal; this is one of the earlier and cruder theories which it is somewhat surprising to find still surviving. It has recently found new expression through Carruthers, the distinguished paleo-botanist, who seems to adopt it without reserve. Several elements of it also enter into the extravagant theory of Grand-Eury which has recently appeared.

(b) An accumulation of vegetation quite after the manner of the mangrove swamps of sub-tropical lands at the present time makes another theory. Geikie adopts this as the best picture of the conditions of coal formation that we can find in the existing order of things.

(c) By Sir Charles Lyell, the cypress swamps of the lower Mississippi were made to do like service. Sir William Dawson seems to agree with Lyell that the conditions of coal formation are most adequately represented by these great accumulations.

(d) Fifty years ago Brogniart made the suggestion in an almost incidental way that we should find in the peat bogs of to-day the analogue and representative of the coal seams of carboniferous time. It is not necessary to claim that a suggestion of this sort had never been made before, for such a claim could not be main-

tained, but the time had come at last for it to strike root. It has been living and growing ever since.

A young Swiss naturalist was perhaps the first to expand the suggestion into a theory of definite shape and proportions. Called by the government of his own canton to report upon its peat beds as a source of fuel, he took up the study of the bog and made himself thoroughly master of its botany, its physics, its chemistry, its geology. He extended his observations and studies, still under government patronage, to the peat bogs of northern Europe until he knew better than any one had known before, the laws of their formation and growth. From peat bogs he came to the study of coal. His field now lay on this side of the Atlantic. He saw, or thought he saw, that the laws of the peat bog could be applied to the coal seam; that the key, the only key, to the history of the latter was to be found in the knowledge that he had already acquired among the beds of fuel that are growing now but whose roots go back into past millenniums.

We should have had a glacier theory of the Drift without Agassiz, a scientific geography without Guyot; and, in like manner, the peat bog theory of coal would have found its way here without Lesquereux; but, historically, it fell to these three illustrious compatriots, fellow students and lifelong friends, to lead the way, each in his own field, to these several great advances. What American science owes to them it would be hard to compute. The obligation will never be repudiated nor forgotten.

In its development, this theory appears to be almost an American theory. It has found far wider acceptance here than elsewhere, and the best statements of it all come from this side of the Atlantic.

It was expounded very ably in the main by Henry D. Rogers in the reports of the First Pennsylvania Geological Survey, but his statement was marred by the introduction of some dynamic features that are quite foreign to our present thought and in which he has no followers.

Newberry has made one of the most compact and symmetrical statements that has yet appeared, and he came to the subject with large and fresh and independent knowledge from every part of the field. The late Prof. E. B. Andrews repeatedly presented the theory in excellent shape, basing his statements in the main on his own observations.

But it still remains true that in view of the central and far-reaching claims of the theory, no thoroughly worthy or adequate presentation of it has ever yet been made. We can go further and say that no near approach has yet been made to such a presentation. All the statements that we have are limited to a few pages each, designed for popular use and falling far below the demands of scientific completeness and exactness.

What better service could be rendered to the geology of coal than a full and adequate explication of this theory? To my mind it holds the same relation to coal formation that the glacier does to the Drift. Without either, we can manage to explain, after a fashion, a great many of the facts involved, but the explanations are halting and inadequate. From peat-bog and glacier are derived the master-keys that fit to every ward of the complicated subjects with which they are connected.

While, therefore, there are considerable differences of view as to the modes in which vegetation was accumulated in the Carboniferous swamps, these differences concern points of minor value. All of the leading theories have a great deal in common and we can scarcely count this subject, more than the preceding ones, among the problems in regard to the more complete solution of which we need to feel great responsibility or urgency.

4. I have glanced at the problem of the coal swamp and the accumulation of a single seam, but these seams are always found combined in great systems, interstratified with sandstones, conglomerates, shales, limestones and beds of iron ore, the whole series measuring hundreds and sometimes thousands of feet in thickness. We are confronted, then, with the problems of a *coal field*, and we bring to our interpretation of it the points already made, viz., that every seam was accumulated by vegetable growth in swamp or marsh or bog near the sea-level.

It goes without saying that subsidence of the coal-forming area must be invoked. The swamps are successively buried under sediments brought in from the adjacent sea, or, more infrequently, by sheets of limestone that grew in the invading water.

To see what some of the problems of a coal field are, let us take a concrete case. I will select the northern extension of the Appalachian coal-field, as it is found in Ohio. It is by far the most orderly field that has ever been described. There is a regularity and simplicity of structure in it that make it the type and standard

for this whole class of formations. The questions connected with a coal field are found here in their simplest form. There are no folds in its strata, and very few arches, and these few are low and gentle. There is not within the limits of the field a fault that deserves the name. Its reliefs are almost wholly due to erosion. The dip is remarkably steady and uniform, and inasmuch as it very rarely rises as high as one degree, it can be determined only by triangulation. The series that is found on one side of a hill can be depended on, with like intervals and relations, on the other. The general order of its most important beds has long been known, the great economic interests involved leading to their early and continuous exploitation on the largest scale.

What then do we find in this, the simplest and most symmetrical, the least disturbed and complicated, of all known coal fields?

We find a maximum of 2000 feet of strata, covering 10,000 square miles of surface.

Of what does this series consist? Irregularly distributed through it, but most largely in the lower portion, are found six or eight strata of sandstone that can be followed with a good degree of steadiness throughout the field. They have their names and places in the scale. Part of them are conglomerates, characterized by the presence of quartz pebbles which sometimes are of large size and form the bulk of the stratum. These sandstones and conglomerates constitute the largest single element of the series.

Next to them in aggregate thickness are beds of shale, frequently replaced with sandstone layers, the shales being gray, blue, black or red in color and gathered in the largest quantity in the upper half of the coal measures.

There are a dozen sheets of limestone distributed irregularly through the entire series. All of them are thin. They are often measured by inches instead of by feet, but they hold their places in the scale with wonderful tenacity. Half of them are of marine origin, as is clearly shown by the abundant fossils which they contain, and, on the same grounds, the rest are found to be of fresh or brackish water origin.

Always associated with the limestones and often replacing them, are ten or twelve deposits of iron ore, some of them of large economic value.

Distributed throughout the entire series and giving name and

character to the whole are fifteen or more seams of coal, ranging from a black mark to a dozen feet in thickness. The valuable phases of the seam are uncertain and unsteady, but the *horizons* are persistent and distinct, to a wonderful degree. Each, as we know, stands for a land surface.

With the seams of coal, and far more extensive and steady than they, are beds of fire clay, of varying degrees of purity. Almost every coal seam is underlaid by clay, and the limestones and ores are also covered or supported by them in many cases.

How are these elements distributed? By no means at haphazard, throughout the scale, as it might appear at first sight. A well-marked and rhythmical order of arrangement comes into view that even he who runs may read. The three elements of those already named that stand for life, that represent the agencies and forces of life, are always found in close proximity to one another. Coal, standing for the life of the land, limestone for the life of the sea, iron ore, equally dependent on life for its separation and concentration, but blended with both limestone and coal, these form vital nodes in the series, relatively of small amount but containing all the economic interest and value. The intervals between the nodes are occupied by the sandstones and shales, already described as forming the bulk of the series. They are, for the most part, barren of life, and owe their accumulation to inorganic forces. Measured against the products of life, these sandstone intervals have a thickness of five or ten feet to one. But note, these intervals are approximately equal. In every part of the field, some normal measure will be found that will recur again and again in the sections we shall meet, as we rise with stair-like regularity from coal to coal or from one limestone to another.

These are some of the facts of this typical district, and as we review them, the problems of a coal field come into sight.

(a) This approximate regularity of intervals between the vital nodes, for example, this recurrence, a dozen times repeated, of the cycles of life,—what explanation is given, what theory offered to account for so obvious, so interesting and important a line of facts? The oracles are dumb. In their work in the coal-fields thus far, geologists have been so busy in answering the economic demands that arise, that most theoretical questions have been pushed aside to await a more convenient season.

One suggestion we have and one only that I know which may

furnish the groundwork of an explanation. We are indebted for it to that unique contribution to modern science, "Climate and Time," a work in which astronomy and geology have met together and geography and physics have kissed each other.

The suggestion of Croll that the Carboniferous Age was a period of high eccentricity and that the coal seams were formed during interglacial stages, revolutionary as it appears, has in it elements that may be able to serve us in attacking more than one of these problems. An astronomical cause for the recurrence of these cycles of life, which exhibit an almost astronomical rhythm and order, is a light in a dark place, albeit the light is thus far but a feeble one.

Newberry has already suggested that the beds of conglomerate associated with the coal beds and to which reference has already been made, need the transporting power of ice to account for them in their present locations.

(b) Let me ask your attention for a moment to this problem of the conglomerate. I do not refer to the old ground of contention, now happily removed by larger knowledge, as to how much the term should include, but consider a single example of a typical bed. Overhanging the Scioto Valley at its most easterly limit in Ross and Pike counties in southern Ohio, is a ledge of pebble rock that caps the hills with its massive walls and picturesque towers. The formation is one hundred feet thick. It is composed, almost without exception, of white quartz pebbles, some of which have a volume of three or four cubic inches. Upon it lies the lowest coal, which again is covered by fifty or sixty feet of conglomerate sandstone in which smaller pebbles are sparingly distributed.

From what shores, near or distant, were these pebbles derived? Who knows a beach anywhere in the world to-day, the pebbles of which are exclusively quartz? How were they gathered up, how transported, how accumulated on these quiet shores in piles one hundred feet in thickness? I know of scarcely the semblance of an answer. It is idle to talk of the glacial drift as furnishing an analogy. Both contain pebbles, but there the likeness ends.

You may answer that geology has not advanced far enough to account for the sources of its materials in any field, but in most other formations, though we cannot go back to the actual sources, we can at least find possible sources of the mineral elements which

compose them, and the facts pertaining to them fall into line with our observations and experience elsewhere. But here all is anomalous and unique.

The fact that such vast masses of altogether similar conglomerate underlie the lower coal measures in nearly every quarter of the world where the formation occurs, adds to the complexity of the problem. If it were at a single point or at a few points that the quartz pebbles were gathered, it would be easy to frame a theory to meet the case, but the universality of its occurrence sweeps away all local explanations.

No wonder that one perplexed student after another has invoked the ill-understood laws of concretionary force to account for these rounded masses of silica, beneath and interstratified with the coal; but the pebbles are stubborn and refuse to be relegated to any other category, and the problem of their origin remains unsolved.

(c) Certain other pebbles, occasionally found in more immediate connection with coal beds may be named here as raising questions as to their history that have not yet been answered. In the heart and substance of coal seams these pebbles occur. There is but one seam in Ohio from which they have been reported hitherto, but this is our most important seam, viz., the Middle Kittanning or Nelsonville coal. At one point in Vinton County where the seam is largely mined they are often brought out. A dozen are sometimes found by the miner in a single day. All that I have seen are hard and flinty metamorphosed sandstones, and are commonly pronounced gray quartzite. From the same seam in Perry County, a boulder of the same mineralogical character, weighing not less than four hundred pounds, was taken, the coal being normal above and below it. The boulder rested on the main parting, the so-called "second slate" of the seam.

Here again both origin and transport are involved. If the pebbles were of the ordinary sandstones of the sub-carboniferous measures, which were already rising above the sea on the margin of the field, there would certainly be less difficulty in accounting for them; but they are metamorphic rock and their nearest source must be hundreds of miles away as we have been accustomed to say. How should a block weighing four hundred pounds be brought into the very centre of our greatest coal swamp and lowered there to rest in normal coal? The questions remain unanswered.

(d) The relation that several of the limestones of the series bear to the coal seams belonging in adjacent parts of the scale raises questions to which we are now not able to give full and definite answers. The facts are familiar to all who keep acquainted with coal measure geology. Four limestones of the Conglomerate and the Lower Coal Measures, viz., the Lower Mercer, the Upper Mercer, the Putnam Hill and the Ferriferous, in other words the two blue and the two gray limestones, severally cover the coal seams that belong next below them, often without the interval of an inch of clay or shale or other deposit. In other words, the limestone makes the roof of the coal, literally and truly.

These limestones are fossiliferous, abundantly charged with brachiopods, corals, bryozoa and crinoids, the latter being especially characteristic. But all of these fossils are marine and mainly stand for clear water, and therefore for areas beyond the line of shore sediments and turbid currents. The two formations, then, which are in immediate contact now, go back for their origin to quite opposite conditions. The coal seam bears witness to the land, or at least its swampy border, where it is now found, and the presence of the limestone is proof throughout its own area of a clear if not a deep sea. These conditions that meet so abruptly now seem incongruous, and the facts must receive more careful consideration than they have thus far received before the solution of the problem can be counted satisfactory.

I have glanced at a few of the unsettled questions that confront us in this, the simplest of all coal fields, but more important ones remain, involving the extent and reach of the several seams and the laws of growth of the field as a whole. These must be passed with but a word.

Here is the Ohio coal field, with its eastern, northern and western boundaries well defined and well known. Were the lowest coal seams formed over this entire area? Have we a right to expect their presence within the central portions of the basin if we descend deep enough? Were the earlier seams progressively covered with the swamps of all the later coals, and were the last the widest in extent?

These questions and others of like import are variously answered by our highest authorities, and they must therefore be counted open; but the affirmative replies seem to me so irreconcilable with the facts of the field and with the first principles

and established laws of coal geology that I cannot for a moment doubt that they will ultimately be abandoned and discarded.

Let me state a few propositions touching these points that it would be a pleasure to expand and support.

(1) The present coal field of Ohio, at the beginning of the carboniferous age, was occupied by an arm of the sea, the slowly growing Cincinnati arch making its western boundary.

(2) Around the shores of this ancient gulf, marginal swamps of wide extent existed, which, by their long-continued growths and subsequent fossilization, became the earliest coal seams.

(3) While the swamps were successively submerged and covered by shales, sandstones and limestones, derived from or formed in the adjacent sea, and were finally covered by other swamps, the continental nucleus was slowly growing to the southward, as it had been growing from the earliest records, and with it the Cincinnati arch united, by a like advance to the eastward, the combined movements gradually expelling the waters of the gulf and converting the earlier formed portions of the coal field into dry land.

(4) Every successive coal-forming swamp thus had a narrower area than its predecessor.

(5) As all the coal seams were formed at the sea level, so all were raised by the continental growth to an approximate equality which their outermost outliers still retain.

(6) To look for the earlier formed seams in the center of the basin would be to look for the living among the dead.

I must leave here the problems of our coal *field*. The half has not been told. The narrowing limits of my hour will give me time to do little more than name the remaining and in some sense the most important of the problems of coal that I have upon my list.

5. Of the several varieties of coal that are found in the Appalachian field, some are either not accounted for at all or are not accounted for alike by geologists.

(a) Even the time-honored theory which ascribes the origin of Pennsylvania anthracite to metamorphic changes induced by the heat of flexure and mountain making in the Appalachian revolution has recently been called in question. On this side of the Atlantic, Hunt maintains, and in his new view seems to have support from other eminent geologists, "that the change which results in the

conversion of organic matters into anthracite was effected before the disturbance of the strata, that the hydrogen was removed in the forms of water and marsh gas, and that differences in aeration during the processes of change and consolidation of the carboniferous vegetation are adequate to explain the differences between anthracite and bituminous coals."

It is, however, very hard to believe that so rational, so self-consistent and apparently so strongly supported a theory as the old one will be found without valid foundations.

(b) For the striking and important distinction that exists between different seams of bituminous coal, by virtue of which they are classified as open-burning and coking coals, no explanation is offered. The factor to which we should first look in accounting for the difference, viz., the percentage of so-called bituminous matter, chemical analysis has ruled out and we know that the difference does not depend on this element.

The suggestion that differences in the kinds of vegetation from which the seams were severally derived will account for the presence or absence of the coking quality is a plausible and increasingly probable one, but it is, thus far, a suggestion only. The question does not seem to be beyond the reach of modern methods of inquiry. Let us hope that it will soon be attacked.

6. On the chemical side there are various unsettled questions pertaining to coal, some of which possess both theoretical and practical interest. I can do little more than to name one or two of them at this time.

For the last twenty or thirty years a vast deal of chemical skill has been spent in the examination of coal. Processes have been perfected and apparatus adapted until little is left to be desired in all these respects. Analyses, ultimate and proximate, have been multiplied to an enormous extent.

Have we any adequate results to show in return for all of this exercise of accurate knowledge and refined skill?

The answer, I fear, must be unfavorable. A large part of this analytical work represents but little and, therefore, has but limited application. Take the method that has commonly been employed in sampling the seam for analysis. A block of six or eight cubic inches is counted ample and it is naturally taken in most cases from the most promising part of the seam. Sometimes that illusory, that impossible thing, an "average sample," is sought and

supposed to be found. The character of the seam is gauged by these results.

But in all this we ignore the vital fact that a coal seam of fair thickness is almost always a complex deposit. It is rarely undivided in structure and still more rarely homogeneous in composition. The several benches that compose it may differ as much from each other as distinct and widely separated seams. The fragment that represents the best phase of the best bench may have but little in common with the balance or with the great bulk of the seam.

For reasons like this, a large majority of the earlier analyses of coals have their chief value in the chemical skill which they display. For the purposes for which they were undertaken, viz., that they might serve as guides in the practical use of the various coals, they are, to a greater or less degree, failures.

But the difficulty lies much deeper than I have thus far indicated. Supposing the coal seam to have been thoroughly sampled and that the analytical work has been accurately done, two conditions which it is by no means hard to meet, do the results of analysis, under these circumstances, enable us to determine with scientific precision the value of the coal examined or, in other words, the work that it will perform? We are obliged to confess that they do not. There are notable discrepancies between the observed and the calculated calorific power of coals, the difference in some cases amounting to fifteen per cent.

In short, the best authorities on the subject declare that neither the calorific power nor the calorific intensity of a coal can be calculated from a knowledge of its chemical composition. These results will depend on the state in which the several elements exist in the coal and on the chemical transformations going on within it during the process of combustion.

The problems of the chemistry of coal are probably not insoluble, but science must sink its roots deeper before it can give full answers to our questions.

7. The last topic that I shall ask you to consider is the microscopic structure of coal. I shall discuss it with special reference to what remains to be done in this field. It is what has been already done that gives us our grounds of confidence in regard to the most important characteristic of coal, viz., its vegetable origin. To the microscope we owe the demonstration of this fundamental fact.

I cannot stop to pay tribute to the various authors from various lands to whose labors we owe this great conclusion, but it would be wrong to pass without mention the splendid contributions of Sir William Dawson. In lifting the veil from the old coal swamp and in causing the light of clear and definite knowledge to penetrate its recesses, no work in the English tongue, need I introduce such a qualification, is, in its adaptations to general service, for one moment to be compared with *Acadian Geology*.

But as I have already reminded you, ours is the day of *thin sections*, and the new means of research must be extended to even as intractable and seemingly unpromising material as coal. We are reaping already the first fruits of what is sure to be a great harvest.

Huxley, without being the first to examine coal in this way, seems to have been the first to draw conclusions from thin sections, in the large way, as to the origin of coal. In his well known paper in the Contemporary Review, published in 1870, he states his conclusions as to the composition of the "Better Bed" seam of Yorkshire. They were to the effect that coal in the main consists of the sporangia or spores of lycopodiaceous plants, the spores being of the same general character as commercial lycopodium, but that leaves, stems and other tissues make some contribution, especially to the so-called mineral charcoal of the coal. The presence of spores in coal was known long before Huxley's announcement. Several years earlier, Carruthers had declared that some coal seams of considerable thickness are almost entirely made up of spores, but to the paper in question the credit is due of making the first significant use of the presence of spores as revealed in the thin section. The claim that was based on the facts was undoubtedly too general and sweeping, and contradictions came thick and fast from all coal fields. The question has remained about in this condition until the present year, when a well marked advance has been made. In May last, Mr. Edward Wethered read before the Royal Microscopical Society of Great Britain a paper "On the Structure and Origin of Carboniferous Coal Seams." In this paper, to which I acknowledge great indebtedness, he records the results of the microscopic examination of several well-known coal seams of Great Britain that were *treated differentially*. Recognizing the compound structure of every considerable seam, to which I have already called your attention, he adjusted his methods to the facts. Obviously it is as unsafe to draw conclusions as to the physical

structure of an entire seam from a microscopic examination of a single layer as it would be to deduce its chemical composition from the analysis of a like fraction of a seam.

Taking several well known coal seams of the British fields Mr. Wethered has made a detailed examination of them, inch by inch and foot by foot, and the results are most instructive.

Ten inches of the uppermost portion of the Better Bed of Bradford, the seam which furnished the foundation for Huxley's paper, submitted to such examination, are reported as follows:

"Within the first two inches from the top, largely made up of macrospores and microspores.

"Three inches from the top, spores less numerous. The mass largely made up of hydrocarbon and decomposed vegetable tissue.

"Four inches from the top, spores again numerous but do not constitute the whole mass.

"Between four and five inches from the top, spores less numerous; vegetable tissue occurs generally carbonized.

"Between six and seven inches from the top, spores form but a small portion of the coal; it is mainly made up of tissue and hydrocarbon.

"Eight inches from the top, spores scarce. Coal made up of tissues in various stages of decomposition.

"Nine inches from the top, a few spores noticed. The coal practically made up of tissue and hydrocarbon.

"Ten inches from the top, spores continue scarce."

In other words, spores constitute the bulk of the coal only in the uppermost three or four inches.

A section of the Splint Coal Seam from the Whitehill Colliery near Edinburgh gives the following record:

"Splint coal, dull luster with a few bright layers,	1 ft. 10 in.	Mass of spores and spore cases.
"Rough coal, bright and dull lustrous layers alternating,	10 inches.	Hydrocarbon in the bright and a few spores in dull layers.
"Lower Splint, dull lustre, with thin bright layers,	4 inches.	The dull lustrous layers a mass of spores. Bright layers, hydrocarbon.

In other seams reported the spores make a much less conspicuous showing, but the facts given attest their very great importance in coal formation.

This line of problems with us is not only unfinished but has not yet been fairly begun.

I have already exceeded the proper limits of an address of this character and must hasten to an abrupt conclusion, leaving without mention several questions of like range and interest with those already raised.

I have passed in brief and incomplete review an important division of geological science and have been obliged to confess at every turn the presence of questions more or less serious to which our answers are as yet fragmentary and unsatisfactory and to some of which we make *no* response. The economic side of the geology of coal has been well developed among us, but in regard to its scientific geology, aside from paleo-botany, while the harvest is plenteous, the laborers are few. Let us hope that some of our younger associates, equipped with all the instruments of modern research, will be attracted to this inviting field.

If I seem to any to have betrayed the weakness of our position in these frank confessions, I will simply remind you that these confessions are intended for the initiated and not for the *profanum vulgus*.

Compared with the full and rounded knowledge of the field to which we aspire and to which science is steadily and swiftly moving forward, all the truths that we now hold *seem to us* as the scattered pebbles on the beach while the vast *ocean* stretches before us untraversed and unknown; but *compared* with the *lack of* knowledge and self-consistent *theory* that marks the *thoughts of* all other men upon these questions, our knowledge seems even to ourselves large and luminous.

The great English dissenter, Robert Hall, sometimes fell into fits of despondency when he surveyed the gulf that separated his sermons from his ideals, and at such times it seemed to him that he could never enter the pulpit again. In one of these moods, he invited a good brother from the country to address his London congregation and sat by and listened with the self-complacent orator, radiant over his great opportunity, unravelled his metaphors and paraded his platitudes. At the close of the service, Mr. Hall heartily thanked the stranger for the good the sermon

had done him and assured him that he himself was now ready to begin preaching again.

So, I suspect, we feel when Philistines lay unconsecrated hands upon the ark. To any of this class who should reproach us with the inadequacy and uncertainty of our knowledge in regard to coal, for example, what should we reply?

We should answer in terms somewhat like these: "As geologists, we know where coal lies in the great column, 100,000 feet thick, of the stratified rocks of the earth's crust. Show us the fragments of a leaf of a land-plant, the tooth or scale of a fish, the broken valve of a brachiopod shell, the smallest, most insignificant relic that life has left forgotten on the shores it has deserted, and we will tell you from this single fragment, very likely, whether or not coal can lie buried beneath you, whether you must ascend in the scale or descend to find its place, and how far.

"As geologists, we know when we meet in the coal field a thin, apparently insignificant sheet of limestone, of a certain sort, how far below it, to a foot, the drill must descend to reach the horizon of the lowest coal, how many seams can be passed in the descent and where, what character of coal will be found in each and the thickness of each, if in normal development.

"As geologists, we know of what coal is composed. We know that it was formed from vegetable growth. We know the approximate place in the vegetable kingdom of the plants from which it was derived; their port and bearing are in our mind's eye, their graceful fronds, their towering, verdant trunks. We know their roots, their stems, their bark, their wood, their pith, their leaves, their flowers, their fruits.

"As geologists, we know not only where and when the work of coal formation went on, but we also know *how* it went on, to what agent it was due. The essential work was done in that wonderful laboratory, the vegetable cell; it was primarily due to the energy of the rays of the sun, 'of this great world, both eye and soul.' For millenniums of millenniums, those potent floods of light and heat were poured down upon the Carboniferous swamps. They were absorbed there in the processes of plant growth, were locked up in leaf and stem and spore, and in this state were buried beneath the sediments which the sea strewed far and wide over the old marshes. They are at last converted into stone, become a part of the earth's rocky crust and are henceforth subject to all the

mutations of this crust, are elevated, depressed, warped, folded eroded, metamorphosed; but through all they retain their original nature. They still contain, literally and truly, the light and heat, the power, of the earlier day that gave them birth. Men learned at last how to use these long-buried stores and, under the discovery, the world springs forward with a velocity never dreamed of before, 'down the ringing grooves of change.' It is the application of the power of coal that makes it true, 'Better fifty years of Europe than a cycle of Kathay.'"

All these things we *know*. Must not such knowledge "grow from more to more?" Can we not be sure that the little problems relating to coal which now rise before us as unfinished will sooner or later find their solution?

But when they are solved, will all be known? Nay, verily. Out of these old Carboniferous swamps, new questions, larger, deeper than any we now see, will perpetually arise, to stimulate by their discovery and to reward by their solution, that *love of knowledge for its own sake* which makes us men.

PAPERS READ.

APATITE DEPOSITS IN LAURENTIAN ROCKS. By Dr. T. STERRY HUNT, Montreal, Canada.

[ABSTRACT.]

THE author noticed the early history of the occurrence of apatite in the Laurentian rocks both of Europe and North America, and its occurrence disseminated in beds of magnetite at Port Henry, N. Y., and elsewhere, as well as in true veins with calcite, quartz, pyroxene, orthoclase, magnesian mica, etc., alike in New York, New Jersey and Canada. He recalled his early pnblished accounts of these in 1848, and the subsequent history of the economic development of these apatite deposits in the provinces of Ontario and Quebec. Besides small veins, sometimes a few inches wide, often cutting the stratification of the gneiss, are large deposits, two hundred feet or more in breadth, clearly posterior to the gneiss in which they are included. These, which have occasionally been traced for distances of several thousand feet, are clearly great veins and contain besides the minerals named above chalazite, titanite, zircon, sphene, pyrite and sometimes graphite. Masses of granular green pyroxene, and others of an aggregate of this mineral with orthoclase and quartz, form a large part of the veinstone. At other times, calcite with crystals of pyroxene, apatite and phlogopite, is the veinstone, or else a nearly pure crystalline fluor-apatite is more or less regularly distributed in bands or masses, often of large size, among the other venous materials.

The banded or gneissoid structure (often nearly vertical) displayed on a considerable scale in the aggregates of these veins is a remarkable illustration of the generation of such structure in highly inclined attitudes by concretionary deposition, and of its independence of sedimentation. The mining operations at each one of several mines near the Lièvre river in the province of Quebec are now yielding from 300 to 600 tons a month of commercial apatite, and these workings afford rare opportunities for geognostical study.

A PROBABLE CAUSE OF THE SHRINKAGE OF THE EARTH'S CRUST.

By WILLIAM B. TAYLOR, Smithsonian Institution, Washington, D. C.

THE widely accepted belief that the present irregularities of stratigraphic disposition have resulted from surface contraction consequent on secular loss of the earth's interior heat, has of late years been so successfully assailed by critical estimates, that the hypothesis can be no longer regarded as tenable. The explanation was undoubtedly based on a true cause; but this has been proved to be an entirely insufficient one. That the varied plications and uptiltings of the geologic crust indicate an enormous stress of lateral compression is too apparent to be questioned. Some other cause for this great tangential thrust must therefore be sought either to supplement or to supersede the theory of a cooling contraction.

Laplace's memorable announcement that the length of the sidereal day had not changed by so much as the hundredth of a second during historic times, "was of a nature to create some difficulties for the physicist;"—as the ingenious Julius R. Mayer remarked in 1848, in his *Celestial Dynamics:* since tidal friction ought theoretically to lengthen the day by some appreciable quantity in the course of 2000 years. It is true that secular contraction by cooling should have the opposite effect of shortening the day; but it could be hardly supposed that these opposite tendencies should just balance each other; though this seemed to be the only conclusion accordant with astronomical calculations.

These calculations of the Moon's motion were revised by Mr. John C. Adams, of England, and in 1853, he showed that a series of terms neglected by Laplace as unimportant, effected a notable difference in the result. He announced that with this correction only about one-half of the moon's acceleration is referable to the diminution of the earth's orbital eccentricity (as declared by Laplace), leaving a residuum of five or six seconds of angular acceleration per century to be otherwise accounted for.[1] This bold statement awakened a lively interest among astronomers and mathematicians; and the searching investigations of a Delaunay

[1] *Phil. Trans. R. S.* June 16, 1853, vol. 144, pp. 397-406; and *Monthly Notices, R. Ast. Soc.* vol. 14, pp. 59-62.

in France, and of a Cayley in England, gave in each case a full and independent confirmation of Adams' conclusions. It was accepted at once that this residual amount of lunar acceleration is only apparent; that it is really due to the continued retardation of the earth's rotation by tidal friction; and thus the anticipations of the physicist were fully corroborated by the later calculations of the astronomer. As Sir William Thomson has stated: "The tides must tend to diminish the angular velocity of the earth's rotation; and this tendency is not counterbalanced to more than a very minute degree by the tendency to acceleration which results from secular cooling and shrinkage."[2]

Mr. George Darwin who has largely discussed the problem of the tidal effects on terrestrial rotation from a remote past, remarks: "The ellipticity of figure must have been continually diminishing, and thus the polar regions must have been ever rising, and the equatorial ones falling;" but concerning these changes, he adds, "they might quite well have left no geologic traces."[3] But the question occurs — have they not indeed left very important, very radical geologic traces? Is not their history written in every range of mountain folds, in every series of corrugated rocks? If we may venture to carry backward geological chronology to an epoch when the day was but one-fourth of its present term, when the equatorial radius was one-tenth greater than it now is,—when therefore the equatorial bulge was 396 miles higher than at present, and the polar regions 658 miles lower,—we should have a condition of the earth's crust, probably quite competent to have produced by continual collapse and compression throughout the greater portion of the terrestrial surface, all those cortortions, foldings and dislocations which form the groundwork of our structural, dynamical and physiographical geology.

George Darwin in a supplementary discussion makes the generalization,—"There can be little doubt that on the whole, the highest mountains are equatorial."[4] And yet (remarkably enough) he does not in any way associate this with the diminution of the earth's oblateness; referring the phenomenon rather to the maximum influence of tidal friction or resistance in the terrestrial crust, over the middle latitudes.

[2] *Nat. Philos.* 1867, vol. 1, sec. 830, p. 686.
[3] *Phil. Trans. R. S.* Dec. 19, 1878, vol. 170, p. 532.
[4] *Phil. Trans.* (same vol.) p. 589.

Mr. Osmond Fisher, apparently the only writer who has pointed out that the diminution of oblateness ought to have produced some appreciable effect on the conformation of the earth's surface, concludes: "There is however no apparent reason to connect the inequalities with this cause."[5]

Dr. Arnold Guyot, in a paper on the "Earth," has remarked: "On the whole, the reliefs begin with the vast low plains around the polar circle, and go on increasing from the shores of the Arctic Ocean toward the tropical regions. The highest elevations however are not found at the equator, but north of the Tropic of Cancer, in the Old World (in the Himalayas, 28° N. lat.); and north of the Tropic of Capricorn in the New World (in the Andes of Bolivia, 16° S. lat.)."[6] And also, "the ocean basins become less deep toward the north pole, just as the lands become lower toward the same region."[7] Does not this impartial testimony form a most suggestive though unconscious indication of the secret cause of orogenesis, leading us to recognize in the wrinkles of our aged globe the monuments of that strange infancy of the distended planet, when the day of but three hours' duration, alternated with as short a night?

THE RECENTLY DISCOVERED SOURCES OF NATURAL GAS AND PETROLEUM IN NORTHWESTERN OHIO. By Prof. EDWARD ORTON, State Geologist of Ohio, Columbus, O.

[ABSTRACT.]

WITHIN the last year, a new horizon of high pressure gas has been discovered in Ohio. The field is located in Hancock, Wood, Allen and Sandusky counties, so far as now developed. Findlay is the main centre of present production and a description of its wells will give the general features of the field.

The surface rock of the district is either the Niagara limestone or the waterlime. The drill descends through 250 to 400 feet of nearly solid limestone, including the formations named above and also the Clinton limestone. The lower part of the Clinton forma-

[5] *Physics of the Earth's Crust*, 1881, chap. 14, p. 183.
[6] *Johnson's Cyclopædia*, vol. 1, p. 1455. [7] Same work, vol. 3, p. 918.

tion is often shale and sometimes the whole of it has this constitution.

Below the divisions already named, 800 to 1,000 feet of shale are found, divided by the driller into red, gray or blue and black shales. The upper division ranges from 50 to 200 feet in thickness and is prevailingly but not uniformly red in color. It is non-fossiliferous and destitute of calcareous matter. The second division consists of 300 to 400 feet of gray or grayish-blue shale, highly calcareous and charged with fossils, some of the fragments of which, as found in the drillings, are identifiable. The lowest section is a mass of dark brown or bluish-black shale, fairly homogeneous in character, sparingly fossiliferous and carrying a notable percentage of lime.

The gas is found in a sheet of solid, impure limestone which the drill has penetrated for 500 feet without going through. The gas belongs in the uppermost beds and no increase of supply has been found after going below twenty feet in the limestone.

The interpretation of the section is clear and unambiguous.

The red shale is of Medina age; the blue section is unmistakably Hudson River, as shown by its fossils as well as by its lithology and its place in the scale. In the same way the black shale is known to be Utica. The most characteristic fossil of the Utica, viz., *Leptobolus insignis*, Hall, has been found in the drillings. The gas rock is the uppermost division of the Trenton limestone.

The relation of the new territory to the Cincinnati anticlinal deserves to be noted. The top of the Trenton limestone

At Findlay is	310	feet	below	ocean	level.
At Bowling Green,	387	"	"	"	"
At Lima,	446	"	"	"	"
At Fostoria,	471	"	"	"	"
At Fremont,	696	"	"	"	"

The axis of the arch is thus shown to be thirty miles or more west of the line previously laid down for it, and thus far the productive territory is found on the top of the arch. No general conclusions are to be drawn, however, from this occurrence, as the number of instances is still too small to be used in drawing a conclusion.

The gas carries a small amount of hydrosulphuric acid, by which its presence in minute quantities is readily detected. It is of fair illuminating quality.

The wells of Findlay are, at present, six in number. Their daily flow has been measured by the anemometer. According to this method of measurement, the yield of one of the smaller wells is 82,000 cubic feet *per diem*, and one of the larger wells was found to yield 1,294,000 cubic feet. The total daily product of the Findlay wells probably ranges between 3,000,000 and 4,000,000 cubic feet.

Petroleum in notable quantities has been found in the same horizon, both at Lima and at Findlay. The oil is dark colored, known as "black oil," has a gravity of 35° to 36° B. and is not high in lubricating quality. It has also an offensive odor, owing to sulphur compounds present in it. It has not yet been shown that the production can be made large or reliable or that the oil will be of considerable commercial value.

The conclusion that the oil and gas are derived from the limestone seems necessary. Attention is called to the fact that all of the limestone oils are black, sulphurous and of about 35° gravity.

A new horizon of these substances and an entirely unexpected one is thus added to the Ohio scale. The Berea grit is the source of all the main supply of gas in eastern Ohio and also of the oil in the only field of Ohio in which the production attains importance, viz., the Macksburg field. The Berea grit is also believed to be the source of the high pressure gas of Pittsburgh. But here we find a lower Silurian limestone, yielding both gas and oil and the former in valuable amount.

DISCOVERY OF FOSSILIFEROUS POTSDAM STRATA AT POUGHKEEPSIE, N. Y. By Prof. WILLIAM B. DWIGHT, Vassar College, Poughkeepsie, N. Y.

[ABSTRACT.]

THE presence of rocks of the Potsdam group, in association with the limestones and shales of Dutchess Co., N. Y., has long been suspected on stratigraphic grounds, but until the present time this fact has never been proved by positive paleontological evidence.

Stratified quartzite rocks, lying between the Archaean at the bases of Stissing and Fishkill Mountains and the overlying Cal-

ciferous and Trenton limestones, have been referred by Professors Mather, J. D. Dana and others to the Potsdam epoch, on these evident stratigraphical grounds. But neither the search of former, nor of recent days, has revealed any fossils by which this most reasonable hypothesis might be established.

I am not aware that any special attention has been given to the possible occurrence of Potsdam strata among the limestones of the county.

The observations recently made in the Wappinger valley (or "Barnegat") limestones, have proved them to represent, continuously and extensively, conformable strata of the Calciferous and Trenton groups. In carrying out the work, in which I have been for several years engaged, of preparing a detailed stratigraphical chart of this district, on April 25 of this year, I struck a ledge of rock in the midst of the Wappinger valley limestone belt, which proved rich in Potsdam fossils.

This remarkable locality is on an estate belonging to Mr. A. K. Smiley, Proprietor of the "Lake Mohonk House;" it is in the outskirts of the city of Poughkeepsie, about one mile southwest of Vassar College, 850 feet southerly from the southwest corner of the Driving Park, and 2200 feet west of the road leading southerly from the same. The Potsdam rocks are here found in a series of low hills or ridges, trending northeasterly and southwesterly; but the most interesting paleontological features are found in the northernmost one. This is about 300 feet in width and 1,400 feet in length. It is mostly covered with soil, the ledges of rock cropping out so slightly that it would never have attracted my attention, but for occurring within the range of a systematic survey.

Lithologically, the rock is here very variable. It is every where calcareous, all its varieties effervescing freely with acids. It is also everywhere more or less arenaceous, often conspicuously so; from being compact and massive, it changes to a rock fissile into thin slabs, or to one splitting into the thinnest leaves, which are covered with loose sand as they decompose.

This rock passes on the one hand into a smooth, fine-grained, argillaceous limestone, and then into a very fissile calcareous shale, or on the other hand, into a quartzite, somewhat calcareous.

The strata have a general strike of N. 21° East, and a dip of about 55° easterly. Much of the Hudson River shale in the vicin-

ity of these Potsdam rocks has a strike of about N. 46° E. Potsdam fossils occur in considerable abundance in few of the more northern of the hills; but the richest locality found is the most northeastern one. No fossils have yet been seen in these strata, south of Mr. Smiley's estate, excepting stromatocerium which is abundant in many of the exposures of these rocks.

In order to determine the true stratigraphic relations of these strata, I have made a special and detailed examination at this place, of a district covering about a mile and a half square, and embracing an extension of primordial strata of about one mile and a quarter along the strike. Before describing the general results of this research, it should be stated that this Potsdam rock is one of the component members of the most western and by far the broadest of three parallel belts of the Wappinger valley limestones which in this part of the valley rise between the Hudson river shales. In general, all these limestones and shales lie in a series of abraded folds, having usually a conformable strike of from N. 20° E. to N. 30° E. These folds are closely compressed, and pushed over to the west, so that the earlier limestones usually overlie by inversion, the later shales lying to the west of them.

The particular belt of limestone which contains this Potsdam is about 3500 feet in transverse width, at the northern portion of the district under consideration, and 6000 feet in width at the southern portion. This belt terminates towards the north, quite abruptly, along an almost straight line which cuts at apparently a right angle to the strike. This line runs through the south side of the Driving Park. To the north of the latter enclosure, a few hundred feet away, in place of hills of limestone, there rise hills of Hudson River shale, which continue, unbroken, northerly for many miles. There is thus evidently here a line of fault across the strike, between the Hudson River Shale on the north, and the Potsdam, Calciferous and Trenton limestones, on the south. The intervening space is well marked by bogs and springs, and by a level belt of ground.

The stratigraphic relations of the western margin of the belt of Potsdam, have proved far less obvious than those of the northern extremity. But after long and careful inspection, a correct solution, as I believe, has been reached. At the northern end of the Potsdam strata, immediately to the west of the fossiliferous hill, is another, and parallel hill, whose western base is about 300 feet

from the western margin of the first one; it is also an arenaceous limestone, running in many places into a brecciated conglomerate. A careful consideration of all the evidence has made it clear that this hill, and its extension to the southwest, also belong to no other than the Potsdam group. Close to the western base of this second hill, is an outcrop of the Hudson River shales, which from this point extend unbroken (unless, perhaps, by some strata of Utica slate) to the Hudson river on the west. This hill of shale, stretching to the southwest for half a mile, is everywhere within a few feet of the limestone, and separated from it either by a chain of ponds or by a deep, dry gully. About half a mile to the southwest, the shales sink into a broad, level plain, everywhere skirting on the west the limestone which now forms a somewhat bold continuous ridge, though mostly covered with drift.

It becomes evident, therefore, that on the west, as well as on the north, there is actual contact between the Potsdam to the east, and the Hudson River Shale to the west; and that the straight line of fault, nearly *parallel* with the strike, is clearly marked by the physical features of the ground.

A fine locality for studying these phenomena is on the west side of the farmhouse of Mr. T. A. Hinkle, and thence a quarter of a mile or more southward. The direction of the line of faulting appears to be about N. 40° E. The Potsdam strata near the line of contact are very generally deflected so as to have less easting, their strike in such places being from N. 4° E. to N. 11° E. On the other hand, to a large extent, the Hudson River shales incline to acquire more easting in the strike, in the vicinity of the plane of contact. In such places they have very commonly a strike of N. 46° E. These shales near the contact are also (as at Hinkle's house) elevated to a nearly vertical position, the usual dip being not more than 50° or 60°.

This fault is the more interesting, because it is evidently related to the great fault described by Sir William Logan and Professor James Hall, as extending from Quebec to the Hudson River near Rhinebeck. If, as seems likely by the latest evidence, this should rather be regarded as a series of more or less parallel faults, the present one would be the most southern of the series yet described.

The limits of this strip of Potsdam on the eastern side, I have found it impossible at present to determine with certainty. That

Calciferous and Trenton strata occupy a large portion of this limestone belt to the east is quite certain; and in at least one locality on its extreme eastern margin, Trenton fossils are present in abundance. But the general absence of fossils and the fact that a great depth of drift covers the larger part of the rock, make it difficult to ascertain the boundary lines of these strata. The true width of the Potsdam is therefore unknown; the minimum width of the compressed folds known to belong to this formation, as we measured on the surface of the ground, is over 600 feet.

From this locality I have already collected over 500 fossils, many of which are imperfect and fragmentary, but some of which are in a very perfect condition. There is no doubt as to the presence among them of several well known Potsdam fossils, and all the specimens appear to belong to the same geological horizon. Not a single Calciferous nor Trenton fossil has yet appeared among the hundreds here collected. These organisms will require a very careful study before any complete list of them can be given.

The following preliminary statement will indicate their nature in general.

1. *Lingulepis pinniformis;* several specimens of both valves, some of which are quite perfect.

2. *Lingulepis minima;* many specimens of both valves.

3. *Lingulepis acuminata;* several good specimens.

4. *Obolella* (*lingulella*) *prima;* several specimens.

5. Obolella, a minute species resembling "nana;" several specimens.

6. Platyceras; undescribed species; two specimens.

7. Remains of small encrinal columns; several.

8. Ptychoparia (Conocephalites); n. sp., resembling Iowensis, but possessing an occipital spine; two or three glabellas and pygidia.

9. Dicellocephalus; two or more species, undetermined; numerous fragmentary specimens.

10. Ptychaspis; one or more undetermined species; several specimens.

11. Stromatocerium; undetermined; abundant.

The more abundant of the fossils are the *Lingulepis minima* and the movable cheeks of trilobites.

It will be observed, as has been suggested to me by Mr. R. P. Whitfield, that the fauna of this locality forms a connecting link between the Potsdam fossils of the Appalachian region and that of

the more western states. Thus, the *Lingulepis pinniformis* of Wisconsin and other western localities is here mingled with *Lingulepis minima* and *acuminata* of New York state.

It may also be remarked that the fauna of this Poughkeepsie locality, so far as now known, is entirely different from that of the primordial strata recently discovered by Mr. S. W. Ford at Schodack Landing and other places in the town of Stuyvesant, N. Y. From these localities, lying about fifty miles to the north of Poughkeepsie, Mr. Ford reports, in the American Journal of Science for July, 1884, the following eleven species:

Paleophycus incipiens, *Obolella crassa*, *Stenotheca rugosa*, *Hyolithes Americanus* and *impar*, *Hyolithellus micans*, *Microdiscus lobatus* and *speciosus*, *Conocoryphe trilineata*, *Olenellus asaphoides* and *Fordilla Troyensis*.

The distinctive character of the two faunas is at once apparent, the former representing probably a later, and the latter an earlier stage of life.

The discovery of the presence of fossiliferous primordial rocks among the Wappinger valley limestones, while adding an extremely interesting feature to the geology of the region, contributes another complication to the difficult task of mastering the stratigraphy of Dutchess county.

SOURCES OF TREND AND CRUSTAL SURPLUSAGE IN MOUNTAIN STRUCTURE. By Prof. ALEXANDER WINCHELL, University of Michigan, Ann Arbor, Mich.

1. THE oldest mountain ranges and the other physiographic features depending on these exhibit, generally, a trend which is approximately north and south. That the whole terrestrial surface is marked predominantly by general trends having a submeridional direction readily appears from an inspection of a map of the world. There are, it is true, many transmeridional trends as the Himalayas; but these are late geological features and not primordial. Still, Asia is shown to be deeply impressed by meridional trends in its north and south bays and river valleys. If the continent were sunken a few hundred feet, the Arctic and the Indian oceans would meet each other along these meridional depressions.

2. The cause or causes of this meridionality must date from the earliest periods of the earth's incrustive history; since geology shows that the grand orographic and continental and oceanic features were marked out as early as the existence of the first germs of the modern saliences of the terrestrial crust, and in their trends no great changes appear to have taken place. These trends are profound and overruling features in all the geological history of the world. It is incumbent on geology to seek their causes. But since the cause lies in the remote domain of facts now obliterated and discoverable only by inference from contemporary phenomena, we have to depart from the direct inductive process in reproducing it to our cognition. By such means we are able to discover *two causes* which must have coöperated in producing meridional trends.

3. The first was *lunar tidal influence*. It is now well understood that a tide in its most general conception is a prolateness of a cosmical body resulting from the differential attractions exerted by another body upon its nearer and remoter sides. It is understood that no known matter possesses sufficient rigidity to resist this bodily deformation; and that the viscosity of matter causes some delay in the attainment, at any place, of the full prolateness due to the action of a tide-producer at that place. In other words, the tide *lags*. In a rotating tide-bearer, the tidal culmination is behind the meridian of the tide-producer. In the earth-moon couple, since the lagging is less than a quadrant, the tidal protuberance causes an excess of lunar attraction on the tidal side of the hemisphere turned toward the moon. This excess opposes the earth's rotation and perpetually diminishes its velocity. The effect of this will be considered presently. Reciprocally, the tidal protuberance acts on the moon, accelerating its velocity and necessitating its slow recession from the earth. As this recession must have continued ever since the moon existed as a separate body, we must contemplate a time when the moon was within a few thousand miles of the earth, and revolving in its orbit with a velocity proportional to the rapid rotary motion of the earth at that time.

During the ages of incipient incrustation of the earth, the moon must have been in a position to exert a vastly greater tidal influence than at present. Whatever the height of the tide, it was also a *lagging* tide. On this the moon exerted its special pull in oppo-

sition to the earth's rotation. But this pull did more. Terrestrial matter was far from rigid. The special pull caused a slight *retral slipping* of the tidal crust. The slipping extended north and south as far as the tidal prolateness — that is, 54° 44′ north and south of the moon's position. As the moon may be supposed to have attained then a declination of five degrees, the slipping action would be felt sixty degrees north and south of the equator.

The slipping action produced similar states in the disturbed crust simultaneously along the meridian passing over the crest of the tide. That is, the movements, the pressures, the accumulations, the internal arrangement of non-homogeneous materials were all distributed meridionally. With the repetition of this action at every point, at every revolution of the earth, deeply ingrained meridional structures were implanted in the forming crust. From these resulted predispositions to meridional distribution of all later physical disturbances of the crust. If through cooling and contraction of the general mass of the earth, wrinkles resulted in the crust, they became disposed longitudinally, instead of being many short wrinkles, without determinate trend. In later ages, however, oceanic pressures or other causes may have overruled the meridional predisposition, now disguised by the rigidity of the thickened crust, much of it also formed since the era of high tidal influences.

It will be noticed further, that the retral slipping would be greatest near the apex of the tidal prolateness, and would diminish north and south in proportion to the diminution in the height of the tide. In other words, the predisposition implanted would not be strictly meridional, but from the average position of the equator would trend north-northeast on the north and south-southeast on the south. This effect is traceable in the actual configurations.

4. The second cause of meridional trends was *diminution of the earth's rotational ellipticity of figure.* The equatorial protuberance subsided as rotational velocity diminished. In other words, this cause resulted in a decrease of the equatorial circumference and an increase of the polar circumference. An excess of lateral pressure was experienced about the zone involved in the equatorial protuberance. That zone was of the same width as the tidal swell. The pressure was from east to west. Simultaneous crustal conditions, therefore, trended from north to south.

This trend was necessarily imparted to all mechanical disturbances of the crust. The cause coöperated with direct tidal action in determining the trends of the great features of the earth's surface.

5. These primitive actions shed light on the problem of the *excess of surplusage in the crustal folds and plications of the mountains.* Fisher, Dutton and others have apparently shown from calculations that the cooling of the earth from the incrusting temperature to the present would not, by contraction, shorten the circumference of the earth sufficiently to supply the convolutions which exist. Claypole has indicated from measurements across a portion of the Appalachians that the convolutions reveal a very marked excess above any supply attributable to contraction from cooling. Now the secular subsidence of the equatorial protuberance may rationally be assigned as an adequate cause supplementing contractional influences.

All these results are primarily tidal, and show that in the physical history of the earth the moon has exerted a profound modifying influence; and lead to the belief that in the history of the moon the earth must have exerted an influence which has been controlling.

GLACIATION OF THE LACKAWANNA VALLEY. By Prof. JOHN C. BRANNER, Indiana University, Bloomington, Ind.

[ABSTRACT.]

EXPLANATION of certain phenomena connected with glaciation can best be sought in the careful and detailed study of small glaciated areas and in connection with the topography. By a small area is meant one having a well defined topography, such as the Lackawanna and Wyoming valleys in Pennsylvania with their bordering mountains. The evidences of glaciation are here seen in many places, and the shales and sandstones of the coal measures, the Pottsville conglomerate, the Mauch Chunk red shales preserve the glacial striæ well. Unfortunately, the Pocono sandstones which generally form the tops of the mountains do not preserve them well. The region shown on the map was gone over very thoroughly, and very nearly, if not quite all, the exposed glaciated sur-

faces examined. The direction of striæ is shown by red arrows on the map. Many cases were observed of variation in the direction of striæ. These variations appear to occur only where the topography has influenced the direction of the glacier. The bearing of the striæ in the Lackawanna valley varies from S. 5° W. to S. 45°W. the prevailing direction being about S. 20-30° W. In the vicinity of Dunmore, striæ in one locality varied from S. 16°W. to S. 42° W.; a difference of 26°.

Toward the top of the conglomerate ledge east of Mocanaqua there are at least seven different bearings discernible in well defined striæ. One of these points S. 30° E. and the one showing the greatest divergence from this bears due west, a difference of 120°.

At the Nanticoke gap the direction of the striæ on top of the mountain west of the village is S. from 5° to 20° E., or nearly at right angles to the trend of the mountain. In the bottom of the gap they point down the narrow valley, N. from 70° W. to due W., a difference of as much as 130°.

At the foot of the steep hill just north of the Mocanaqua station striæ vary from S. 10° W. to S. 40° E. It was not possible in all cases to determine beyond a doubt which of these striæ were made last. Generally, however, there is one set broadly and deeply scored. The variation is, I believe, due to the influence of topography upon the direction of the ice flow. When the ice was at its greatest thickness it flowed high above the tops of the Lackawanna mountains which appear to have influenced the course of the ice very little or not at all. This may be seen in the diagonal course across the mountains and the included valleys. As the sheet became thinner the topographical obstructions had more and more influence until the glacier became a purely local one.

This is well illustrated at the Shickshinny end of the Wyoming basin. The flow along Turtle Run was nearly due west; but these striæ are in a valley 400′ or 500′ deep. On the top of the ridges to the north striæ point S. 20° to 35° and 60° W. At the point above Mocanaqua Station where the variation in direction is so great, I believe the flow came originally over the top of the Shickshinny mountain at a time when the ice was thick enough to disregard such a topographical feature. But as the body of ice became thinner these sharp ridges had a more and more marked effect and gradually changed the course of the thin ice sheet till it ran square down the valley. As it became still thinner the little conglomerate

ridge turned it still further till it ran due west. Such instances are more likely to occur when the high ridges stand at a considerable angle to the flow of the great glacier.

The last glacial epoch must have drawn to a close with a large number of small local glaciers.

There are many instances of upward flow. The best defined striæ are in such places. The difficulty many find in understanding this so-called "upward flow" comes from imagining the ice to be only a thin sheet, in which case it certainly could not flow over hills and mountains. The physical law that carries a glacier over an obstruction a foot high is the same one that carries it over a mountain a thousand feet high, and, in order to conceive of and realize this movement, we must simply imagine the ice so thick that the ridges and mountains are powerless to influence its course. The thicker the sheet the less it would be influenced by topography.

Another difficulty may be caused by accepting Rendu's wholesale definition too literally. He says that "it is impossible to find in the glacier a circumstance which does not exist in the river." The transportation of material is done in a very different manner, the plasticity of the ice pushing the material along and holding it at the same time in its grasp.

NOTICE OF LINGULA AND PARADOXIDES FROM THE RED QUARTZYTES OF MINNESOTA. By Prof. N. H. WINCHELL, State University, Minneapolis, Minn.

[ABSTRACT.]

THIS paper simply called attention to the late discovery of fossils in a series of beds known as red quartzytes that have been by some referred to the Huronian in Minnesota, with an exhibition of specimens, and had a brief statement of the relations of these strata to others.

THE QUATERNARY DEPOSITS OF ILLINOIS. By Prof. A. H. WORTHEN, Springfield, Ill.

[ABSTRACT.[1]]

AN exhibit of sections of the quaternary deposits of central Illinois with brief explanations of the character of the beds.

[1] This paper will be published in full in Vol. XIII, Geological Survey of Illinois.

RESULTS FROM A STUDY OF THE GABBROS AND ASSOCIATED AMPHIBOLITES IN DELAWARE. By Prof. FREDERICK D. CHESTER, Delaware State College, Newark, Del.

[ABSTRACT.]

THE area of crystalline rocks which covers the northern part of the state is a continuation of the well known Philadelphia gneiss belt, consisting of garnetiferous gneisses and mica schists. The gneisses of Delaware are bordered on the south by a club-shaped area of eruptive gabbro, widest in the northeast and gradually tapering to the southwest. The southwestern end, for several miles, is wedged between the mica schists, but further on to the north the Cretaceous clays form the southern boundary of the gabbro. Since the gabbro is known to pass beneath the clay sheet, however, it is probable that the mica schists still lie deeply buried and continue, for the whole distance, to form the southern border of the gabbro. In this case, we must regard the gabbro mass as one intruded between the rocks of the Philadelphia belt, and in every respect a true dike. The rock of this eruptive mass is subject to wide variations resulting in the formation of no less than thirteen species and varieties merging into each other by the most indistinct stages of gradation. The typical form of these rocks is a true hypersthene-gabbro, or a distinctly granular mixture of plagioclase, hypersthene and diallage with accessory quartz, magnetite, apatite and pyrite. In the most intimate association with this are a number of varieties of gabbro-diorite and amphibolite, the two latter usually containing a predominating proportion of a brown, highly absorptive hornblende and of a green pleoclinic hornblende. The brown hornblende is quite fresh and is probably original, while the green variety is derivative, and a paramorphic product from either hypersthene or greenish pyroxene (diallage). These two processes of paramorphism were then described in detail. The southwestern narrow half of the gabbro area, or handle of the club, is covered by the amphibolites and gabbro diorites. Passing to the northwest, however, along the axis of the belt, the amphibolites pinch out and form a wedge-shaped tongue between the massive gabbros which occupy all that region in the vicinity of Wilmington. The boundaries of this wedge are most obscure, the schistose and massive rocks blending most indistinctly. That the amphibolite and gabbro-diorites have resulted from combined paramorphism

and pressure affecting the massive gabbros is established: first, by the study of some seventy-five thin sections from all parts of the belt; second, by the finding of all stages of change from the massive gabbros to the schistose amphibolites; and third, the association of cores of unchanged gabbros within masses of the amphibolite. Those varieties of gabbros which were affected most by the paramorphic process were those containing the largest proportion of the pyroxene elements. The foliation characteristic of the amphibolites was undoubtedly the result of pressure which has affected the whole gabbro mass, but which impressed itself most strongly upon the highly basic rocks whether unchanged gabbros, partly paramorphosed gabbro-diorites or true amphibolites. Further, it was found that the degree of foliation was in direct proportion to the degree of paramorphism, in which event pressure must at least have had an indirect connection with the cause of paramorphism. The following will illustrate the line of petrographical variation from the primary hypersthene-gabbro.

Hypersthene-gabbro. Plagioclase, hypersthene, diallage with accessory quartz, apatite, magnetite, pyrite.	(a) By addition of original brown hornblende — *Gabbro-Diorite.*	By loss of pyroxenic matter and increase of brown hornblende — *Diorite* (massive).
	(b) By addition of paramorphic green hornblende — *Gabbro-Diorite.*	By complete paramorphism of pyroxene to green hornblende — *Amphibolite.*
	(c) By addition of brown hornblende and paramorphic green hornblende — *Gabbro-Diorite.*	By complete paramorphism to green hornblende with brown hornblende — *Amphibolite.*
	(d) By addition of mica, with quartz and orthoclase generally present — *Gabbro-Granite.*	By loss of diallage — *Hypersthene-Granite.*
	(e) By loss of diallage — *Hypersthenite* (a coarse grained mixture of plagioclase and hypersthene.)	By paramorphism of hypersthene to green hornblende — *Diorite* (massive).

LOWER SILURIAN FOSSILS IN A LIMESTONE OF EMMONS'S ORIGINAL TACONIC. By Prof. JAMES D. DANA, Yale College, New Haven, Ct.

[ABSTRACT.[1]]

THE author mentions the discovery of Lower Silurian fossils at several points in the "Sparry Limestone" of Emmons, in the

[1] This paper is printed in full in Vol. XXX of the American Journal of Science and Arts.

town of Canaan, Columbia County, New York, within a mile of the Massachusetts boundary, to the southwest of Pittsfield; and thus sustains the view that the limestones of the original Taconic and the overlying schists of the system are of Lower Silurian age.

The Dakota group south of the Platte river in Nebraska.

By Prof. L. E. Hicks, State University, Lincoln, Neb.

[ABSTRACT.]

I. *General position and extent of the Dakota group.*

The Dakota group is the lowest member of the Cretaceous formation in Nebraska. It rests unconformably upon the Permo-carboniferous and is overlaid conformably by the Colorado group of the Cretaceous period.

This group covers a superficial area of about 5,000 square miles in the state of Nebraska, of which the portion (one-half) south of the Platte river has been examined this season. The eastern boundary of this portion begins near Cedar Creek station in Cass county, curves west and southwest to the vicinity of Roca in Lancaster county, thence south to the Kansas line. The western boundary begins midway of the north line of Saunders county and runs south twenty degrees west to the southwest corner of Jefferson county.

It does not seem probable that the rocks of the Dakota group ever extended eastward much beyond their present limits. The shore line of the sea in which they were deposited has been traced and it is found to coincide very nearly with the present distribution of these rocks.

II. *Thickness, dip and conformability of the Dakota group.*

The average thickness of this group is somewhat more than 400 feet. One section near the Platte river gives 423 feet, one near the Kansas line 447 feet and one midway between these gives 400 feet. The direction of the dip is west twenty degrees north, and it averages about six feet per mile.

A great amount of erosion of the Permo-carboniferous limestone occurred before the deposition of the Dakota group. In some places the bottom of the Dakota is ninety feet below the

level of the adjacent and older limestone, which must therefore have formed cliffs of that height bordering the Dakota sea.

It is a noteworthy fact that the bays which projected eastward along the shore of this ancient sea held the same position now occupied by the river valleys. These bays were caused by the excavation of river valleys previous to the invasion of the Dakota sea, the rivers flowing in an opposite direction to that of the present rivers. Thus, some of the prominent features of the topography of Nebraska were outlined ages ago.

A novel result of the extensive erosion antecedent to the deposition of the Dakota group is that the boundary line between it and the Permo-carboniferous projects eastward in the valleys instead of westward. The deeply eroded valleys would naturally be expected to reveal tongues of the older formation projecting westward, since the dip is west, but the contrary is true.

The unconformability between the Dakota and the Permo-carboniferous is not merely that of erosion, but also that of a lack of parallelism of the planes of stratification. The dips of the Permo-carboniferons are more varied in direction and greater in amount than those of the Dakota, which are uniform and gentle.

III. *Structure and composition of the Dakota group.*

The "beach structure" predominates. There are many fine examples of oblique laminæ, especially near Lincoln, Pleasant Dale and Bennett in Lancaster county, above South Bend in Cass county, and at Endicott and Kesterson in Jefferson county. At Pleasant Dale remarkable curves and contortions of the laminæ were observed. These may be in part due to a concretionary structure. Concretions are abundant, generally coated with carbonate of iron.

The beach structure is by no means universal. In many places the sand s are fine and lie in even layers, indicating quiet water of some depth. Other materials which indicate quiet waters, such as shales and fine clays, also occur.

An impression prevails among geologists who have read the published descriptions of the Dakota group that it is composed almost wholly of sandstone. That is indeed the typical element in its composition, but it contains many other ingredients, and south of the Platte river these constitute probably one-half, or more than one-half, of its thickness. Shales, clays, shaly sand-

stones, lignite, conglomerate and hard grits, or quartzites, all occur, and in some places are more conspicuous than the rusty sandstone which is the typical rock of this formation.

The presence of excellent fire-clay in this group is an important fact in economical geology. It is already the basis of an important industry. All the potteries in the state, so far as I know, derive their raw material from the Dakota group.

IV. *Fossils of the Dakota group.*

The leaves of angiosperms have long been known to be the most abundant and interesting fossils of the Dakota group. Several new localities for the collection of these leaves have been observed this summer and considerable collections made, including some new species.

The fauna of the Dakota group remains, for the most part, a subject of conjecture. Only a few species of marine shells have been discovered. No locality in Nebraska is known to furnish these except one near Fairbury in Jefferson county recently discovered by myself. It is very rich in marine fossil mollusca, and also in the leaves, fruits and wood of various kinds of trees.

V. *Topography of the district underlaid by rocks of the Dakota group.*

Most of these rocks are too soft and too deeply covered with drift and loess to make much impression upon the landscape. Flat or gently undulating surfaces, broad valleys and easy slopes are the prevailing features of the scenery. But some of the sandstones form bold and lofty cliffs, as, for instance, along the Platte river and the Little Blue river and its tributaries, particularly at Endicott and Rose creek in the vicinity of Kesterson in Jefferson county. In this locality we have a very interesting example of the dependence of topography upon geological structure. A series of table-topped hills or mesas have their height and form determined by a hard grit near the top of the Dakota group. The summits of the mesas coincide with the top of the Dakota.

THE RECORD OF THE DEEP WELL OF THE CLEVELAND ROLLING MILL COMPANY, CLEVELAND, OHIO. By Prof. EDWARD ORTON, State Geologist of Ohio, Columbus, O.

[ABSTRACT.]

A DEEP well is now being drilled within the city limits of Cleveland, by the Cleveland Rolling Mill Company, the object of the drilling being to secure a supply of natural gas for manufacturing purposes. The depth of the well at this writing is 2950 feet. The contract calls for a depth of 3000 feet unless gas in satisfactory amount is sooner found. It is probable that the drilling will be extended to 3200 feet before work will be finally suspended. This makes the drilling the deepest in Ohio.

The well-record has been quite carefully kept by the contractor, Mr. J. W. Churchill, to whom I am indebted for the facts herewith given. These facts are in part unexpected and anomalous to a high degree.

The level at which the boring was begun is about 765 feet above tide water. Geologically, it is about 75 feet below the Berea Grit, which occurs at no great distance. The first rock to be reached is the Bedford shale, the hard layers of which are extensively quarried near by. This stratum is succeeded by the great series of Devonian shales which were divided by Newberry into the Cleveland, Erie and Huron divisions, these divisions being marked in his scheme by change of color, the upper and the lower being black and the middle being gray or greenish blue. These shales have a thickness in the well-record, exceeding 1300 feet.

The next element in descending order is a limestone sheet, over 300 feet in thickness, which is referred so far at least as its upper portions are concerned, to the Corniferous limestone, that is so prominent an element in the scale a few miles to the westward.

Thus far no question can arise as to the identification of the strata found by the drill with the beds shown in outcrop to the westward of Cleveland, but from this point downwards, much is anomalous and obscure. No final interpretation will now be offered but the record is made public for study and comparison. It is as follows:

1. Drift, ... 40.′
2. Shales, changing in color from light to dark, with frequent alternations, . . 1310.′

3.	Limestone, solid,	310.′
4.	Sandstone, sharp and clear,	40.′
	Salt water occurs here.	
5.	Limestone,	290.′
6.	*Rock salt* and thin bands of shale,	164.′
7.	Gypsum and shale,	15.′
8.	Limestone,	81.′
9.	*Rock salt*,	50.′
10.	Gypsum, bluish,	40.′
11.	Sandstone,	20.′
12.	Shale,	18.′
13.	Limestone,	22.′
14.	*Rock salt*,	20.′
15.	Shale,	10.′
16.	Limestone,	40.′
17.	*Rock salt*,	5.′
18.	Shale,	8.′
19.	Limestone,	167.′
20.	Hard limestone with petroleum in small amount, high in sulphurous products, near summit of stratum, about	300.′

The drill is still laboring in this solid limestone. While no full interpretations will be essayed, a hint or two as to the order may be ventured upon.

The sandstone, No. 4, 40 feet thick, that is interposed between two heavy beds of limestone may be the Oriskany. The overlying limestone, No. 3, is 310 feet thick, which exceeds any measure that the corniferous attains in New York, Canada or Ohio, in its outcrop.

The rock salt that makes so large and so surprising an element in the section from 2000 feet downwards, Nos. 6, 9, 14, 17 comes more nearly into range, with the Medina, Hudson River and Utica groups than with the Salina, to which it would most likely be referred at first sight.

The oil bearing limestone which was struck at 2656′, and which continues without interruption as far as the drilling has now proceeded, is the Trenton limestone, if we can rely upon the evidence of its petroliferous quality by which it is connected with the new wells of northwestern Ohio.

The well has been a very expensive one to drill as the contract required a dry hole and as new supplies of salt water were struck, from time to time, through the entire descent below 1700 feet. The casing was set and drawn many times, but the 5⅛′ pipe now extends 1856 feet below the surface, probably the deepest iron in the country. But even this inordinate expense has been rendered null and void by the new sources of salt water found in the Trenton limestone and the well is now full of brine.

No gas or oil in quantity enough to be of economic value has been found.

ON THE CLASSIFICATION OF THE UPPER DEVONIAN. By Prof. HENRY SHALER WILLIAMS, Cornell University, Ithaca, N. Y.

OUR esteemed colleague and president of last year gave us a most instructive lecture upon the duty of scientists to do much and say little.

Although I have been able to put in some "dead work", as a foundation for what I have to present to the section, I feel a great diffidence in standing before our veteran geologists with a proposal to interpret a series of rock formations to which they have given indefatigable study, but left still in mystery.

If I shall succeed in throwing a little new light upon the intricate problem, I am sure it will be due to the vantage ground which their great labors give me, and the wealth of suggestions found in their own struggles with the same problem.

The intricate relations borne by the red and coarse gray deposits with brackish-water faunas and floras, called Catskill in their typical region, to the shales and sandstones with upper Devonian fossils and to that third set of faunas called the Waverly, have been a constant source of confusion for the last forty years.

The exposure of these deposits along the southern counties of New York, extending from the Catskill mountains to Cleveland, Ohio, offered a field for study in which the whole problem lay open for solution.

In attacking it, the task I set myself was to so dissect the faunas found in the rocks, as to be able to trace the changes they

might undergo, both horizontally in passing from region to region, and vertically passing upward through the stratified deposits containing them.

This necessitated a careful review of work already accomplished, a gathering of fossils from each separate zone all over the region, a careful study of the species, their varietal modifications and their associations, and all in relation to the stratigraphic and lithologic character, of the deposits containing them. For over three years I have given such time as I could spare from university duties to this study. I have now accumulated enough data to be able to see some results, but they are the mere beginnings of what this method of investigation promises to furnish as a reward for earnest labor.

I have sought to interpret the order and relation of the deposits by a comparison of their faunas.

In this comparison the following criteria were used: the composition of the faunas themselves, the dominance of certain species, the absence at certain stages of species generally present, the entrance of new species into the fauna and the variation of species in form, in varietal characters, in size and in abundance. The comparisons were made in two directions, furnishing one series of geographic modifications of the faunas and another series of geologic modifications recorded in the several stages of each fauna. Most of the faunas were found to present distinct geologic stages characteristic of successive horizons; these were characterized by the dominance of a few species, the particular combination of the species, and the varietal modification of species more or less conspicuous throughout the fauna.

The condition of the rock masses, over the region studied, has offered almost unparalleled advantages for carrying on this line of study.

They are found to lie nearly horizontal for the whole area, dipping scarcely as much as one hundred feet to the mile for any part, and generally not over fifty feet. Slight undulations have complicated them in the more southern exposures, but these are regular and easily allowed for.

The danger of possible error, arising from placing too great confidence in an assumed general uniformity of dip, was constantly checked by observation of the actual altitude of the strata at dif-

ferent exposures, and of their rise and fall whenever two sections were near enough together for precise comparison.

The local stratigraphical observations have been made as far as practicable along parallel lines, running entirely across the series from north to south, which was from below upward.

These observations have been combined to form a series of meridional sections, ten of which are sufficiently well perfected to place on the chart. I have represented them in their proportionate thickness; they are placed on the chart in their relative distance apart. (See chart, pp. 235–6.)

The following sections are seen, beginning at the left:

I. The Cuyahoga section, Dr. Newberry's typical section in the neighborhood of Cleveland, Ohio.

II. The Painesville section, through Painesville, Ohio.

III. The Girard section, of Erie Co., Penn.

IV. The Chautauqua section, beginning in Chautauqua County, N. Y., and terminating in Erie and Crawford Counties, Penn.

V. The Genesee section, terminating in the Olean conglomerate, or its equivalent in McKean County, Penn.

This is the typical section of the fourth district of the final reports of the New York State Survey. It has served in the New York reports as the basis of classification for the upper Devonian.

VI. The Canandaigua section, through Canandaigua lake. Mr. Berlin H. Wright and Prof. J. M. Clark have added some data to those found in the state reports relative to this section.

VII. The Cayuga section. This passes from Cayuga lake southward, and lies between the third and fourth sections of the original survey.

This section was adopted in 1839 and 1840 as the standard, but for some reason, not stated in the reports, was abandoned.

Had the original plan of the geologists been strictly followed out I believe much of the confusion that has occurred would have been avoided. With this belief I made a special report upon this section, which will be found in the Third Bulletin of the United States Geological Survey.

VIII. The Tioughnioga section, running through Cortland and the Tioughnioga valley.

IX. The Chenango section of Chenango valley.

X. The Unadilla section, of Otsego and Delaware counties. The sections comprise the strata from the upper Hamilton to the conglomerate which introduces the Carboniferous deposits.

The Hamilton terminates in the Genesee black shale, which forms a well defined continuous horizon.

The whole series records a change in the conditions of the region, from seas depositing limestone, to shores accumulating coarse conglomerate and holding land plants.

In this series of sections several distinct sets of faunas were seen. These I have designated by letters, and their several stages by numbers after the letters.

A is the Hamilton fauna and its immediate successors.

B is the black shale fauna, beginning in the typical or first stage of the Genesee shale.

C is the fauna of the green shales of the typical Portage group.

D is the Chemung fauna associated with brown argillaceous shales, flags, or calcareous sandstones.

E is the fauna of the flat pebble conglomerate.

F is the fauna and flora of the Catskill grays and reds.

G is the Waverly fauna.

H is the conglomerate (Olean and equivalent).

J is the Barclay coal beds.

The comparative study of these faunas led to their classification into temporary stages, based upon some one or more of the secondary data before mentioned. These stages are represented on the charts by the numbers following the letters, and I have given them provisional names in the following table, taking generally the name of some dominant genus or species:

The nomenclature of species is that of the official state reports, and does not express my adoption of it as final.

In this subdivision of the faunas the following stages have been recognized:

The middle Devonian fauna (A) was traced above the horizon of the Genesee shale in the following successive stages:

A 1, the *Paracyclas lirata* stage.

A 2, the *Spirifera lævis* stage.

A 3, the *Strophodonta mucronata* stage.

A 4, the *Atrypa reticularis* stage.

A 5, the *Leiorhynchus globuliformis* stage.

A 6, the *Tropidoleptus carinatus* stage.

A 7, the *Spirifera mesostrialis* stage.

A^6+ is a second recurrence of the *Tropidoleptus* stage, found above the Chemung fauna and distinguished by the variety *Owegoensis* of *Spirifera marcyi*, a characteristic variety of the *granulifera* type of *Spiriferas*.

In the fauna of the black shales:

B, the Genesee stage of *Lingula spatulata*.

B 1, the second *Lingula spatulata* stage, in Portage shales.

B 2, the *Lingula complanata* stage, of the "Ithaca group."

B 3, *Lingula spatulata*, third variety, in the Cleveland shale.

B 4, *Lingula complanata*, second stage, in Chemung shales.

In the Portage faunas, C:

C 1 is the Cephalopod stage, with *Goniatites* and large *Cardiadæ*.

C 2, the Lamellibranch stage, with *Cardiola speciosa*, etc.

C 3 is the Portage sandstone, generally barren.

These faunas are mainly in the greenish argillaceous shales.

The faunas of the brown shales and sandstones of the Chemung deposits were classified into the following stages:

D 1, the stage of *Orthis tioga*.

D 2, " " " *Strophodonta cayuta*.

D 3, " " " *Athyris angelica*.

D 4, " " " *Rhynchonella contracta*.

D 5, " " " *Spirifera alta*.

All of these stages, except the first (D 1), are characterized by the presence of some variety of *Spirifera disjuncta* (= *Sp. Verneuili*).

In the Catskill rocks the fossils are very rare, but there are two stages (F 1) of the Oneonta reds and grays and (F 2) of the typical Catskill. So far as fossils have been found there is difficulty in defining them.

It is probable that *Holoptychius* and several allied fish, Conrad's *Cypricardia angusta* and several plants are found in both alike, but further investigation will be necessary to establish any clearly distinctive characters in the fossils.

The Waverly fauna G appears to be distinguished into three

stages in other parts of Ohio. But in the region comprised in these sections the stages are recognized more by their lithologic than by their paleontologic characters. The general fauna may be called the *Syringothyris* fauna,

With G 1, the Bedford shale stage,

With G 2, the Berea grit and sandstone,

With G 3, the Cuyahoga shale and sandstone.

Taken as wholes, each separate fauna is found to possess certain characteristic geographic limitations.

Above the Genesee horizon the successors of the Hamilton fauna (A 1–7) are confined to the more eastern third of the area.

The Genesee shale fauna (B) has a wide range, but it is wanting in the extreme eastern sections. Its upper recurrence is recognized by traces even as far as the Chenango section, but on following it westward it is frequently recognized in thin seams or in black streaks of the shales containing some of the same species all the way up. Even the more dominant species of the Cleveland shale, as I have before shown, are those found in the western representatives of the Genesee shale.

The *Cardiola* fauna of the Portage (C 2) is most abundant and characteristic in the central part of the area. It has been traced eastward as far as the Cayuga section, but I have not detected it any farther east. The characteristic green argillaceous shales with which it appears to be associated are also not recognized in the more eastern sections.

The Chemung fauna (D) has been seen, in what I regard as its earliest stage (D 1 on the chart), in the Cayuga section, and is there the first fauna above the final stage of the *Cardiola* fauna, (C 2). Traces of it appear above the Portage sandstone (C 3) of the Genesee section, but it is depleted, only a few species appearing there. The middle stages (D 2 and 3) appear all through the central part of the area, but are wanting in the more western and the more eastern sections. The fourth stage (D 4) is confined to the sections of Chautauqua and Girard, until near the termination of the Chemung deposits, when it spread eastward, and is the only stage of the Chemung fauna recognized at the eastern extreme and there only at the very termination of the marine deposits. *Spirifera disjuncta* and *Rhynchonella contracta* are almost the only species found in this upper fauna, but in the western sections (the Girard and Chautauqua) these species occur

very early in the deposits, the latter having been found as low as the Portage flags of White's classification.

The Catskill fauna (F^2) for this region is confined to the eastern sections, the Waverly (G) belongs to the extreme western sections. Species of the Waverly fauna, however, extend eastward and nearly meet the westward extension of the Catskill at about the Genesee meridian.

The lithologic character of the deposits appears to be intimately associated with the distribution of the faunas.

The green shales of the Portage group change to blues of the Hamilton as we pass from the Cayuga section eastward. The Chemung deposits pass out in the same way by changing from brown argillaceous shales to gray, gritty shales as we go eastward and toward the Catskill areas.

These changes are not caused by the thinning and thickening to any considerable extent, of the stratigraphic masses or their individual strata, but by a gradual change in the nature of the sediments deposited at a common horizon, but at different distances from the source of the material. This is proven by the order of the faunas. The fauna which appears at the upper stage of the green shales in the Girard section (the Girard shale and upper Portage of I. C. White) is restricted to a higher and higher horizon going eastward, so that in the Chenango section it is the last fauna seen below the reds, but going in the opposite direction the sequent of the Hamilton fauna appears at lowest level in the more eastern section and in the Cayuga section has reached up into the horizon of the middle Chemung.

The evidence proves that the faunas were more separate, more limited to their local areas at the base and the species which continued to live became distributed and the faunas blended in the upper horizons.

Some interesting features in the more eastern of these sections have been brought to light by the investigations. Much perplexity has prevailed in regard to the preliminary stages of the Catskill group. In the first reports of the New York survey the Catskill stage included some rocks which are now regarded as below the Chemung stage.

The discovery by Mr. Way, in Delaware county, of fossils of Chemung character above red beds, led our eminent New York state geologist in 1863, to disclaim the Catskill age for most of

the Catskill deposits of the state, and at the same time Col. Jewett, then curator of the State Museum, expressed his belief that there was no Catskill whatever in the state.

Later investigation led Professor Hall to re-recognize the Catskill, but its lower limit has been matter of great dispute.

The reds of Otsego and Chenango counties had been regarded as Catskill, and were associated by Vanuxem as "Oneonta and Montrose sandstones." Until 1880 the presence of *Cypricardites* was regarded as characteristic of the base of the Catskill. A very similar, if not identical form, *Anodonta Jukesii*, is described from British old red sandstone.

In 1880 the superposition of beds containing marine Devonian fossils was taken as evidence of the distinctness of these lower reds from the true Catskill, as an Oneonta group. The presence of *Holoptychius* was then regarded as the sign of a genuine Catskill horizon.[1]

With this as a history of the region, and the fact that undoubted *Holoptychius* has been repeatedly reported with and below Chemung faunas (or the upper Devonian marine faunas), in this country as well as in Russia and Belgium, I went into the field this summer for the purpose of finding where and how these reds intruded among the marine faunas.

I would also add that this region of Chemung and Broome counties had never been thoroughly understood. Vanuxem reported Hamilton and Portage where Chemung fossils were expected.

I went into the region expecting that a study of the order of the separate faunas would throw light upon the subject. I give the facts, well aware that the observations I have to present have not so heavy a foundation of "dead work," that new light may not be thrown on them by future exploration.

I observed that the fauna A 1, underlying the grays which initiate and terminate the reds, was composed of Hamilton species with scarcely any exception,—that is, species that are known to occur below the second black Devonian shales.

West of the reds are faunas of the lower and middle Ithaca group, including the *Spirifera lævis* faunas and the great part of the fauna containing Hall's *Strophodonta mucronata*. Above the

[1] See New York State Geological reports, 1840, pp. 393 and 453; 1841, pp. 41, 75; Final Reports of 1842 and 1843. Canadian Naturalist, 1862, Vol. VII, pp. 377, 395. Regents' Reports, 1872, 24th, pp. 9–10; 1873, 23d, pp. 7–8. Proc. A. A. A. S., 1875, p. B, 80–. Science, 1880, Vol. I, p. 290. Proc. A. A. A. S., Pt. 2, p. 246.

barren grays and reds the first species are *Tentaculites* and broken crinoid stems; these are evidently associated with a transition stage, as they characterize similar transitions at other horizons and are often all that is seen.

The next marine fauna recognized is the latter stage of the Ithaca series of faunas, the *Atrypa reticularis* stage of the general *Strophodonta mucronata* fauna, then comes the *Leiorhynchus globuliformis* fauna, then the *Tropidoleptus* fauna, then the wider-spread fauna of *Spirifera mesostrialis*.

In the Tioughnioga section the same series in the same order is recognized, but the reds and grays are absent, and the middle and lower stages of the Ithaca fauna occupy the place filled by the reds in the Chenango and Oneonta sections.

In the Cayuga section only traces of the *Leiorhynchus* fauna are seen. This is followed above by upper Portage flags and shales with the *Cardiola speciosa* fauna of the Portage and recurrent traces of the black shale fauna, but mainly barren for 600 feet. Then follows the first of the Chemung faunas, and above well-defined Chemung faunas is a recurrent but later stage of the *Tropidoleptus* fauna, in which many of its species occur but with some modification of the type. To show how distinctly Hamiltonian it is, I would simply mention the presence of *Tropidoleptus*, *Cypricardella* (*Microdon*) *bellistriata* and *Phacops rana*.

This fauna was seen farther east, above the first stage of the *Tropidoleptus*, but with no trace of the Chemung fauna detected. No trace of it has been reported or detected west of the Cayuga section as here described, which includes the Chemung narrows exposures. The grays above the first reds carry fish plates which I believe to be of the same species with some I have seen associated with genuine corrugated *Holoptychius* scales in McKean County, Pennsylvania. I have not yet had opportunity to make accurate identification of them, but every character of the beds leads to the identification with Catskill deposits except their relation to the overlying deposits.

The fact of their stratigraphic position is already granted, and their relation to the faunas which represent them westward and follow them stratigraphically appears to be established with a considerable degree of certainty by the facts here presented. I was aware of the doubts that might lie in the way of the acceptance of these observations and used every precaution to protect myself

against hasty or rash conclusions. As the facts developed from day to day, I wrote down what, according to the light I had, should be observed at a certain altitude in the next adjoining exposure. I had my able assistant and associate, Mr. C. S. Prosser, go ahead, observe the altitude, take the specimens and send to me. Invariably the packages contained the fossils I expected to see.

On tying on my observations to the Pennsylvania section in Susquehanna county, I found that Prof. I. C. White, in the report on Wayne and Susquehanna counties, cited several species in his Cascade section as common and abundant which, according to my observation, belonged to the western extension of the Chemung fauna, and should not be the prevailing fauna in that locality according to my theory. This I noted before going into the field.

When I examined the section I found no trace of several of the species cited and only rare and imperfect specimens of *Spirifera disjuncta* and the last stage with *Rhynchonella contracta*, but all the mass of the fauna was *Spirifera mesostrialis* and its legitimate associates, which is a lower fauna belonging to the more eastern part of this general area. The difference between the two *Spiriferas* appears at first glance slight, but they are clearly distinct.

It has been suggested that the peculiarities of this region might be due to faults, or to great variation in dip. In reply to this and as an example of the value of the study of faunas for settling such questions, I will cite but one example. On studying up the Chenango section we were unable to get a single continuous section from the first red beds up into a distinct exhibition of the marine faunas. I calculated from our other observations that the first fauna above should be either the earlier stage of the *Leiorhynchus globuliformis* fauna, or the closing stage of the *Strophodonta mucronata* fauna. When, finally, we found a continuous section in the neighborhood of Sidney and Bainbridge, the facts were as expected,—a few traces of the *Strophodonta* fauna first, then the *Leiorhynchus globuliformis* fauna in typical representation.

From these studies I believe it is safe to deduce a few general principles:

First. The complications arising from both geological and geographical modifications of fossil faunas are so great that the attempt to determine horizons by single or by roughly identified fossils will certainly lead to erroneous results.

Second. In classifying deposits in geologic surveys, it is of the

greatest importance that the actual altitude and the geographic position of rock strata should be precisely defined, as well as the lithologic character of the strata themselves. And for this purpose some systematic and uniform nomenclature for the various kinds of rocks should be made and adopted by all geologists in the country.

Third. The fact that species composing the faunas, and the total faunas themselves are subject to constant modification, both geographic in the same horizon and geologic in the same area, is an element that paleontologists cannot safely ignore; these modifications, though they may be slight, can be easily recognized in the passage of fifty miles.

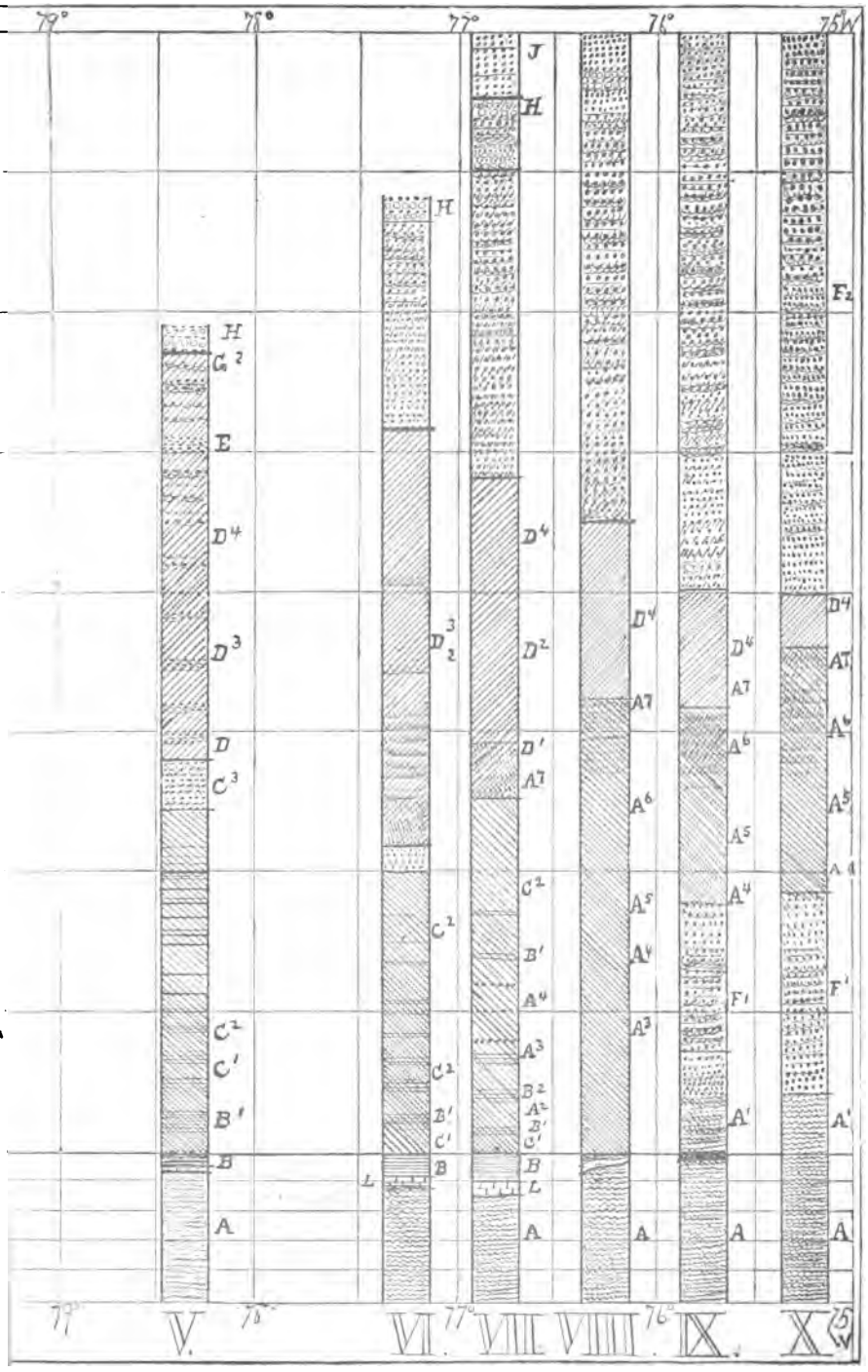
Fourth. The actual order of faunas met with in a vertical section is not necessarily expressive of biologic sequence, but signifies the sequence of the occupants of that particular area.

The change in the species from one stratum to the next may express the shifting for miles of the actual inhabitants, and if the change, within a few feet of strata, is to an entirely distinct group of species, the evidence should be taken as pointing to a considerable shifting of condition of the bottom. If in such case each fauna is kept distinct, the means of tracing the geographic distribution and modification are at hand. If mingled, then the collection, though made at the same locality, will only confuse. Two such faunas meet at Owego, Tioga county, in distinct strata, but in rocks which are of similar lithologic character; one is a remnant of a prevailing western fauna, the other is an eastern and late stage of a new fauna.

Fifth. The classification of the rocks may receive local geographic names; the classification of the biologic series should receive names derived from the names of species; ages defined by families, periods by genera, and epochs by species, or something of that kind, and these periods or ages will always adjust themselves to future discoveries.

In this way, and only in this way I believe, can we hope to keep any sharp lines of limitation for our geologic classifications. Thus a Portage shale or a Genesee shale will ever be what they are called. When they cease to be sandstone or shale they must go under other names, and the equivalents will be designated by other names. A *Strophodonta mucronata* stage will extend up and down, east and west, wherever the species constituting the proposed essentials of the fauna exist together.

OF NEW YORK, PENNSYLVANIA AND OHIO.—BY HENRY SHALER WILLIAM



The newly discovered range of a species will be recognized as important to note, but the expansion of the limits of the range of the fauna will not interfere with any of the marks of precision used in the science.

The bearing of these studies upon the classification of the geologic deposits concerned tends to support the following conclusions:

1. That the Devonian black shales carry a fauna (B) which reappears with slight modification wherever the black shales appear, from the Genesee shales up through the Portage deposits to the Cleveland shale and possibly higher. These deposits run out and disappear at the eastern extreme of the area.

2. The Portage rocks and their fauna (C) are comparatively local, belonging to the central part of the area, the fauna failing in the more western sections, and both fauna and lithologic characteristics are unrecognizable east of the Cayuga section.

3. It is evident from the study of the sections, that the interval occupied in the Genesee section by the typical Portage fauna is represented in the Cayuga section by an entirely different set of species (the several stages of A), while still farther east in the Chenango and Unadilla section the same interval is filled by a preliminary stage of the Catskill (F 1).

4. The Ithaca group, of the state reports, contains faunas (A 3–4) which I have defined as stages in the successive modifications of the Hamilton fauna. This set of faunas differs from the Chemung fauna in the absence of several of its common and abundant species, and by presenting unmistakable evidences of earlier stages in modification of species which are near enough alike to be classified under the same specific name.

5. The series of modified stages of the Hamilton fauna (A 1–7) is confined to the sections east of the Canandaigua meridian.

The lowest stage (A 1) occurs at the extreme east, where the Tully limestone and the black Genesee shale are scarcely to be recognized. The third and fourth stages do not appear at the extreme east, but only in the Cayuga and Tioughnioga sections,—their place farther east being occupied by the first stage of the Catskill.

The following stages appear in the more eastern and fail in the Cayuga section, while the final stage (A 6 and A 7) extends farther

west, and appears after the Chemung species have appeared in the deposits of the region.

6. The Catskill deposits of Chenango and Otsego counties are intrinsically not distinguishable from the upper stage of the Catskill, but appear at a lower position stratigraphically in the interval occupied by the "Ithaca group" of the Cayuga section and by the middle part of the Portage group of the Genesee section; but paleontologically they are immediately preceded by stages of the Hamilton fauna and are followed by later stages of the same general fauna.

7. The Chemung fauna appears, in what I consider its earliest biologic stage, in the central sections (D and D 1), but the predominant and most characteristic species of the Chemung appear stratigraphically earliest in the more western sections (D 4 of Girard and Chautauqua). This stage of the fauna appears in the upper part of the Chemung group of the more eastern sections, and when we reach the more extreme part of the area (the Chenango and Unadilla sections) this stage of the fauna is all that appears and is there represented by a few specimens in the very upper strata just before the final incursion of the Catskill deposits.

The investigations, upon which this paper is based, were begun privately and with my classes in Cornell University. For the last three years they have been conducted in connection with the United States geological survey, for which a monograph upon the Devonian faunas is in preparation.

Ithaca, August, 1885.

WESTWARD EXTENSION OF ROCKS OF THE LOWER HELDERBERG PERIOD IN NEW YORK. By Prof. S. G. WILLIAMS, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

GENUINE Lower Helderberg rocks other than those of the Water Lime group have a greater westward extension in New York than has hitherto been supposed. It has been stated that they are confined to the eastern part of the state, and thin out entirely before reaching the western boundary of Oneida county. On Cayuga Lake, however, there are about seventy feet of impure limestones below the Oriskany Sandstone which are proved to belong to this age by containing at several horizons of their sparsely fossiliferous beds such undoubted fossils of the Lower Helderberg period as *Strophodonta varistriata*, *Spirifer Vanuxemi*, *Rhynchonella semiplicata*, *Anatina? sinuata*, *Favosites Helderbergiæ* and several others, without any intermingling of such forms as characterize the Water Lime group. There are here nevertheless no traces of those marked subdivisions which make so striking a figure in Schoharie Co.; and this is undoubtedly due to the fact that the conditions of deposition in the western localities remained tolerably uniform throughout the age, and admitted little diversification of life forms, while in the east, great physical alternations gave rise to groups of strata which present considerable differences in forms of life as well as in lithological characters.

On the outlet of Skaneateles Lake, about twelve miles east of Cayuga Lake, the thirty-five feet of limestones which are exposed in quarries beneath the Oriskany Sandstone, contain from ten to eleven feet of seams wrought for hydraulic lime fifteen feet below the top of the series, and these seams are underlaid by beds holding *Strophodonta varistriata* and *Spirifer Vanuxemi*, whilst immediately beneath the Oriskany, Stromatopora occurs abundantly, as it does also on Cayuga Lake, the conditions of deposition presenting, therefore, no very considerable differences at these two localities.

At Oriskany Falls, near the southern boundary of Oneida Co., a station tolerably near midway between Cayuga Lake and Schoharie, at least 120 feet of limestones are revealed below the Oriskany Sandstone, of which 115 feet were measured. The upper twenty-six feet of these beds are gray and sub-crystalline, whilst

most of the remaining beds of the series are blue, and so pure as to be largely used for lime-burning and for flux in iron furnaces, with the exception of seven feet of impure, grayish, laminated and occasionally *ripple-marked* beds near the middle of the series. The lowermost strata for at least forty feet contain only fossils which, like *Spirorbis laxus*, *Chætetes fruticosus*, *Tentaculites gyracanthus*, and *Spirifer vanuxemi* associated with *Leperditia alta*, characterize the Tentaculite limestone of the eastern localities, whilst the remaining beds, which are abundantly fossiliferous at some horizons, show a complete intermingling of lower Pentamerus and Delthyris Shaly Lime forms, save immediately beneath the Oriskany Sandstone, where two species of the Delthyris Shaly lime alone were found.

It is inferred, therefore, that at this somewhat central locality a tendency is apparent to a complete obliteration of the marked lithological and palæontological subdivisions which appear in the easternmost regions; and that in the western localities, this simplification of the synchronous strata has merely been carried to almost complete uniformity, with a gradual thinning of the series westward, and with the presentation of conditions unfavorable for the existence of a numerous and varied fauna.

THE OCCURRENCE OF TRAP ROCK IN EASTERN KENTUCKY. By Prof. A. R. CRANDALL, Lexington, Ky.

[ABSTRACT.]

THE only dike known in Kentucky is that which has recently been brought to notice in Elliott county. This dike represents an eruption of very limited extent laterally, and carries with it no characteristic topographical features; the intrusive rock (peridotite)[1] yielding to eroding agencies as readily as do the including coal-measure shales and sandstone.

With reference to the general geology of eastern Kentucky, it is near the border of the coal field; not far from the foot of the S. E. dip of the broad anticlinal of central Kentucky, which in-

[1] The petrology of the dike will be the subject of a paper by J. S. Diller of the U. S. Geol. and Geog. Survey.

volves the coal-measures to the thickness of about 600 feet; or to coal six of the Kentucky reports. The dike cuts a ridge which reaches to that level in two lines which radiate from a common point in the valley of a small branch of the Little Fork of the Little Sandy river, and extend westward into the valley of Isom creek, with two lateral branches, as indicated by the presence of crystals of titanic iron and other remains of the disintegrated dike, and of fragments, more or less metamorphosed, of carboniferous shale. The whole length of either radiating arm is probably less than one mile.

The dike is eight miles S. W. of Willard; the present terminus of the E. Kentucky Railway. It is a few miles outside of the well-marked depression known as the Willard basin. It is also near the westward termination of a belt of country extending from W. Va., in which a strong dip to the north marks the border of a geological tableland, and along which the oil and gas wells of Lawrence and Martin counties are found.

Native antimony and its associations at Prince William, York Co., New Brunswick.

By George F. Kunz, New York, N. Y.

The Brunswick antimony mine is situated in Prince William Parish, York county, New Brunswick, on the right bank of the St. John river, twenty-four miles from Frederickton, and ninety-six miles from St. John, New Brunswick. The locality was discovered about 1860, and a few years later the Prince William, the Hubbard and the Lake George mines[1] were opened; all of these were ultimately absorbed by the Brunswick mine. At the present time this company controls a tract of land three miles by five, containing many veins of stibnite and forming one of the largest antimony deposits known.

In the early working of the mines, native antimony was only rarely observed, and was not even mentioned in the reports of

[1] This locality is briefly mentioned by Dr. L. W. Bailey in a letter to Prof. B. Silliman, see American Journal of Science, 2nd Series, XXXV, 150, 1863. Messrs. Hayes and Jackson also mention this locality in the Geology of New Brunswick by L. W. Bailey, 1865. See also Report of the Geology of New Brunswick, 1865, by Henry Youle Hind.

Prof. G. I. Chase and Wm. Petherick, M. E., in their prospectus of the Brunswick Mining Company.[2] It is mentioned, however, in the fifth edition of J. D. Dana's System of Mineralogy, p. 18, as of rare occurrence at the Prince William mine. The mining then was all merely on the surface, but within the last two years it has been carried on to a considerable depth. At a depth of from 100 to 150 feet the native antimony is occasionally found in large pockets, some of which contain fully one ton of the pure mineral; it is associated with stibnite, valentinite and kermesite.

In its most common form the mineral is very compact and at times finely granular in appearance, resembling very closely the native antimony of South Ham, Canada; in this form it breaks at times with a slightly conchoidal fracture and has a decided steel blue color. The forms in which it occurs are usually either rounded or elongated masses, from ten to twelve inches across, and weighing from twenty to fifty pounds; it passes into a coarse granular variety where it very closely resembles the mineral from Sarawak, Borneo. The most remarkable form, however, is where it occurs in radiated masses of crystalline plates. The single blades are from one to two and occasionally four inches in length and one-eighth of an inch across, being nearly as large as those of the artificial metal of commerce. The radiations seem to have massed around a common center, as if the mineral had cooled or crystallized slowly from without. One fine mass of this radiated tin-white metal measured over six inches across. Very small microscopic crystals, about .05 mm. in size, were developed by removing the calcite with acid, and mention was made of some large ones that had been observed, but these had been lost. Some of the crystalline cleavages have striations similar to those described by Laspeyres[3] that are also observed on the artificial antimony, and on the coarsely grained native variety from Allemont; these he refers to a polysynthetic twinning with 24 *R* as the twinning-plane. The specific gravity of a pure piece of the coarsely crystalline bladed mineral was found to be 6.606 at 15°, and of the very compact, finely granular mineral 6.693. The following chemical results were obtained by Mr. James B. Mackintosh, E. M., School of Mines, New York City:

[2] Reports of Prof. George I. Chase and Wm. Petherick, M. E., to the Brunswick Antimony Co., Boston, 1864.

[3] Zeitsch. Deutsch. Geol. Ges., 1875, p. 574.

Coarse grained variety.

Gangue . .	0.84 per cent.
Iron . . .	0.11 " "
Arsenic . .	0.86 " "

Fine grained variety.

Gangue . .	5.04 per cent.
Iron . . .	0.34 " "
Arsenic . .	0.47 " "

The difference in both cases is metallic antimony free from other admixture in large enough amount for detection, in the quantity used for the examination (one gram.). In working the stibnite and accompanying ores on a large scale, to make the golden sulphuret (Sb_2S_5), gold and silver were observed in sufficient quantities to suggest the working of the ore for these minerals.

Stibnite occurs largely in the quartz veins in a massive form and in small diverging blades, and also in large masses with blades from four to six inches in length, and from one-quarter to one-half inch across. It occasionally occurs also in very small crystals in cavities, usually all of a very dark graphite color. In the seams between the layers of native antimony the valentinite occurs in massive and granular forms; also in beautiful radiations of bunched crystals, the radiations measuring over one and a half inches across. It occurs also at times in small hemispheres and in small isolated imperfect crystals not over three mm. in length.

Kersemite occurs in the cavities in stibnite and the antimony in small tufts of crystals, none of which were observed over one-half an inch in length; it occurs also in small hemispheres as a rule in the cavities in the native antimony. The color is from a dark cherry red to nearly black, and the fracture of the antimony is often streaked with this mineral. Dyscrasite, allemonite, senarmonite and native arsenic were looked for but not observed, though it is highly probable some of these may yet be found.

The country rock is a black argillite, and the veins of quartz and calcite with stibnite which traverse it vary from one to thirty feet; they are similar to the South Ham, Canada, deposits.[4] At the surface one of the principal veins had a dip of S. 80° E. with

[4] Geology of Canada, 1863, p. 876. Report by Charles W. Willimott, Geol. Survey of Canada, 1880, 1881 and 1882, p. 3, G. G.

a depression of 55° N. Several other veins were N. 70° W. and S. 70° E. In following it a westerly direction from the points where the shafts were sunk an increase of dip was observed.

I take pleasure in expressing my thanks to Mr. C. E. Parsons, of the Brunswick Antimony Company, for his kindness in furnishing information, as well as specimens of the minerals for examination.

MINERALOGICAL NOTES. By GEORGE F. KUNZ, New York, N. Y.

Curious form of beryl from Auburn, Maine.

IN my possession is a curious beryl found by Mr. S. C. Hatch at Auburn, Me., of imperfect structure. The crystal is broken diagonally across, thus showing the structure to very good advantage. It is 30 cm. high and 22 wide, and has fifty different layers, twenty-five of beryl, and the remaining twenty-five of albite, quartz and muscovite. All the corners of the hexagonal prism are carried out in full, giving the beryl an asteriated appearance, and making it a striking and interesting specimen.

Capped garnet from Raymond, Maine.

In this connection the fine essonite and other garnets from Raymond, Maine, may be mentioned. As many as a dozen consecutive layers of garnet and calcite are found in one of these crystals. If the layers are removed, a perfect crystal is found within. One of these, a dodecahedron, 12 cm. by 8, breaking at a calcite layer, forms a very beautiful cap crystal.

Artificially stained turquoise from New Mexico.

Numerous parcels of turquoise have recently been sent east from New Mexico and among them were small lots of exceptionally fine blue color for American turquoise. This color did not appear to be natural, but the stones were found to have the same specific gravity as the others from New Mexico, and cut with the characteristic soapy ivory cut. It was only after the back had been scraped off to some depth that the fact was revealed that they were artificially stained turquoise; the coloring matter employed

was the same as used in Germany to make the breccia agate resemble lapis-lazuli, for which the *former* is often palmed off on tourists. In this case, however, the prussian blue is only a superficial staining and the intensity of the blue is modified by the green. It can be easily removed without injury to the stone by scraping the back with a knife. Prussian blue dissolves readily in (NH_4HO) ammonia, so that the simplest test is obtained by washing the stone in alcohol and wiping it to remove any grease and then laying it in ammonia for a moment. The blue color will partially or wholly disappear, and the gem will resume its natural greenish hue.

If it were desirable to examine the stone without destroying the color, it would be better to cover the face with wax, allowing it to project above the back and then pour a little strong ammonia into this groove. If artificial, the difference of the shades on the two sides would be marked. If stones thus colored were worn in rings their color would very soon be affected by the water used in washing the hands. Ammonia does not affect the color of true Persian turquoise, although washing the hands with them on usually does. By artificial light, the color of this stained turquoise is rather gray-blue and appears duller instead of brighter, as is the case with the genuine turquoise. A stone worth 100 to 200 dollars, if found to be stained would depreciate to only one-hundredth part of its original value. This deception is to be regretted since it will cast suspicion on any fine turquoise that may be found in this country in the future; the test is so simple, however, that any one can satisfy himself as to authenticity. I would add that a few stones have been cut from New Mexican turquoise which had, at the time of cutting, a very good blue color, but it changed to the characteristic green within a few days.

Beryls and Garnets from Colorado.

Near Mt. Antero, in the Arkansas Valley, Chaffee Co., Colorado, some very fine blue beryls have been found, resembling in color and general appearance those from Mourne Mt., Ireland. The crystals vary from 25 to 30 mm. in length and 5 to 8 mm. in width, and are quite transparent in some parts. The faces observed were 0, 2–2, 1 of the pyramid and I and i i of the prism. Some of the crystals were perfect enough to furnish small deep-blue gems.

Near Salides, Colorado, large quantities of common dodecahedral garnet crystals, coated with chlorite, have been found, somewhat similar to those from the Lake Superior region. These garnets, however, are only superficially altered and the chlorite is of a lighter color. Some hundreds have been found, equalling in size the crystals from Burke Co., N. C., and averaging about one pound in weight. A number weigh over two pounds and a few range from four to eight and one-half pounds.

The tourmaline locality at Rumford, Oxford Co., Maine.

By George F. Kunz, New York, N. Y.

[ABSTRACT.]

The Rumford tourmaline locality is situated in the northeast part of Rumford town, in Oxford Co., Maine, on the northwest slope of Mt. Black, about 1500 feet above sea-level. The vein has been uncovered for the length of 250 feet, and found to be quite irregular, varying from 30 to 100 feet in width, and dipping northeast and southwest at an angle of about 60°. The rock is a coarse granite with mica schist overlying.

This locality was discovered by Mr. E. M. Bailey, in October, 1878, but the first blasting was not done until July, 1883. The finest specimens were procured in the fall of 1883. The Mt. Mica Co. had some work done here, and since they stopped Mr. E. M. Bailey has worked the solid ledge to a depth of 3 to 10 feet.

The lepidolite found here is finer grained than that from the other Maine localities. One form is in scales not over 1 mm. across, quite compact, and occurs in large masses of a beautiful lilac color, closely resembling the mineral from Altenberg, Saxony. A characteristic form is of a light lavender color, very compact, and has scales not more than 1 to 25 mm. in width, penetrated in every direction by crystals of rubellite, which are of a light or dark shade of red. This association is very similar to that from the well-known locality of Rozena, in Moravia.[1] Rubellite, indicolite, and the green tourmalines, are the common varieties at this locality. Both these minerals exhibit a tendency to radiate, assuming this form also when they occur side by side in one radia-

[1]These forms are so compact that they could be used for ornamental purposes.

tion. Perfect crystals are exceptional. Masses of rubellite 8 cm. long and 4 cm. thick are found. One section of a rubellite crystal with a centre of a lighter color, was terminated almost entirely by a large oplane. Small green crystals with red centres and red crystals with green centres 1 cm. across were observed, and also flattened crystals between plates of a beautiful, silvery muscovite. Fine colored rubellite, almost fit for gems, at the juncture with and in white quartzite. Dark indicolite, in short, imperfect crystals 4 cm. long and 3 cm. thick, was found; also cassiterite in imperfect crystals, one an ounce in weight, on cleavelandite with one bright face; columbite in thin-bladed crystals, some of them 2 cm. by 1 cm. by 1 mm. thick, in cleavelandite. Spodumene was observed in imperfect crystals 7 cm. long, and in fine cleavages 10 cm. by 6, and fine compact amblygonite in masses 4 cm. by 2 cm. Triplite was observed in small, irregular masses.

Future working will evidently bring gems and better crystals to light, though it is doubtful if they will equal those from Paris and Auburn. Dr. A. C. Hamlin and Mr. N. H. Perry kindly provided me with specimens; and Mr. E. M. Bailey has furnished me with considerable information, as well as specimens.

A PSEUDOMORPH OF FELDSPAR AFTER LEUCITE (?) FROM MAGNET COVE, ARKANSAS.

By GEORGE F. KUNZ, New York, N. Y.

[ABSTRACT.]

FIVE years ago one-half of a trapezohedral crystal was sent to me along with a lot of minerals from Magnet Cove, Arkansas. The first glance showed that it was an alteration and not a natural mineral. The only mineral in this locality from which it would be likely to be altered is the well-known crystallized melanite, usually filled with schorlomite. Having often observed a grayish and yellowish alteration on the surface of the melanite and also[1] the altered perofskite from this locality (the hydrotitanite of König) and the altered vermiculite, called protovermiculite by König,[2] it seemed not unreasonable to suppose that this might be one

[1] Proc. Acad. Nat. Sciences, Phila., p. 82, 1876.
[2] Proc. Acad. Nat. Sciences, Phila., p. 269, 1877.

of the same class of decomposition products. This crystal was sent to Dr. F. A. Genth, who kindly analyzed it with the following result:

	(1)	(2)	Mean.		
			Dr. F. A. Genth.	Bergemann, Oberweisenthal	Knop, Vogelsberg.
H_2O	= 2.90	3.00	2.95		
SiO_2	= 60.81	60.72	60.77	60.46	56.61
Al_2O_3	= 22.45	21.80	22.13	22.11	22.92
Fe_3O_2	= 0.45	0.43	0.44	1.98	2.33
MgO	= ——	0.05	0.05	1.22	——
Na_2O	= 0.36	——	0.36	0.53	2.95
K_2O	= 13.91	——	13.91	13.53	13.65
					1.68 CAO
			100.61		

The specific gravities of five crystals were as follows:

No. 1	2.37	very much disintegrated and not well to use.
No. 2	2.43	very compact crystals.
" 3	2.44	
" 4	2.44	
" 5	2.45	
Mean of four crystals	2.44	
Leucite Rocca Monfina	2.444	

This analysis was completed about one year ago, but the portion of the crystal returned was lost, and as the matter had not been fully investigated the results were not published. Until two months ago this was the only crystal that had been observed. At that time two more were found, and within one month more, over one hundred crystals were obtained, thus precluding all doubt of its being of domestic origin.

When an attempt was made to break off one of the crystals, measuring thirty-five mm., that the internal structure might be examined, instead of a complete fracture a shell five mm. in thickness cracked off, revealing a perfect inner trapezohedral crystal. A slice of this extending to the core was taken out by Dr. G. P. Merrill, who reports as follows:

"From my examination of the thin section I find the structure quite homogeneous, but spherulitic, nearly the entire mass being

made up of the small, spherulitic bodies shown in the photograph. These bodies, which are a millimeter, or upwards, in diameter, consist of a central, nearly colorless, mass, non-dichroic, but giving the polarization of an aggregate in faint, iridescent colors. This centre is, in many cases, stained yellowish by metallic oxides. Beyond the centre is a zone consisting of radiating, columnar bodies of indefinite outline, giving no colors between crossed nicols, but showing their greatest extinction nearly always parallel to lines drawn from the centre of the spherulite toward the circumference. The spaces between these columnar bodies are filled with the same colorless aggregate as the central portions of the spherulites. These last, it may be stated, are not in all cases spherical in outline, but often irregularly elongated, having evidently interfered with one another in process of formation. Those toward the centre of the crystal are most elongated, while those toward the outer portion of the crystal are less closely compacted and hence possess a circular outline, as seen in the plate. The difference in shape is, so far as I can determine, the only distinguishing feature between the outer crust of the pseudomorph and the more compact interior.

What I have written, you perceive, furnishes no clew whatever as to what the original mineral may have been, and I am able to obtain no measurements of extinction or crystallographic angles that shall help me in the least."

The fact that the outer shell broke off would indicate that this is a garnet alteration, since the point of breaking may be the point of contact with the schorlomite (usually enclosed in garnet), but the analysis agrees so remarkably with Bergmann's analysis of a feldspar (closely resembling oligoclase in composition) after leucite, from Oberweisenthal, in Bohemia (J. pour Chemie, lxxx, 418), that the facts were not published until more material could be obtained.

This similarity is found, moreover, not only in the analyses, but even in the general appearance of the minerals, which could not be distinguished by a casual observer from the mineral from Oberweisenthal, Bohemia. The large percentage of potash, almost fourteen per cent, would suggest alteration from leucite (Bischof, see analysis of the Rocca Monfina alteration) and it agrees very nearly with Knop's analysis of the mineral from Vogelsberg (Jahrbuch Min., 1865, 685).

The color of the crystals varies from yellowish brown to brown;

internally usually either grayish-white or yellowish-white to light brown; and the structure is very finely granular.

The crystals found vary in size from 10 mm. to 45 mm. and are all trapezohedrons (2, 2). The dodecahedral faces found on the melanite of this locality were not observed on any of the altered crystals. Heretofore leucite has never been observed at this locality, but if this proves to be an alteration from that mineral, leucite may yet be found in its unaltered form and in considerable quantity, judging from the abundance of pseudomorph forthcoming.

METEORIC IRON FROM JENNY'S CREEK, WAYNE CO., WEST VA. By GEORGE F. KUNZ, New York, N. Y.

DURING the early part of last April a 9-oz. piece of mineral, supposed to be silver, was sent to Dr. H. G. Torrey for determination by Major Delafield Du Bois, of Charleston, West Va. On examination, Dr. Torrey found it to be an iron of meteoric origin, and kindly loaned it to me for description. The piece delivered to me was supposed to be all of the fall, and on this supposition it was described as the Charleston, Kanawa Co., West Va., meteorite at the time of reading this paper at the Ann Arbor meeting; but since then by the kindness of Major Du Bois, Mr. J. F. Hoard and Jno. N. Tilden, who went to considerable trouble in ascertaining it, I am able now to announce the true locality.

Mr. Hoard writes that the iron was found on land belonging to Maston Christian, situated on the "Old Fork" of Jenny's Creek, a tributary of the "Tug Fork" of Big Sandy River (Tug Fork being the boundary line between West Virginia and Kentucky), in the upper end of Wayne county. The pieces were all found in the creek bed, *i. e.*, the ravine or gulch through which the creek flows. The first piece, weighing probably two or three pounds, was found by Christian's wife some time earlier than the spring of 1883. It was supposed to be simply a rich "kidney" of limonite, and was soon lost sight of. In the spring of 1883, however, a second piece was found by Christian himself while drifting

staves in the creek. This piece which weighed about twenty-three pounds, created considerable excitement and speculation. It is even stated that a shrewd speculator, who had in his possession a lump of the metal, had realized largely by burying it on different lands, digging it up again, and then selling the pieces of property successively as being silver bearing. The rumor was current that the vein was from nine to sixteen inches thick. It

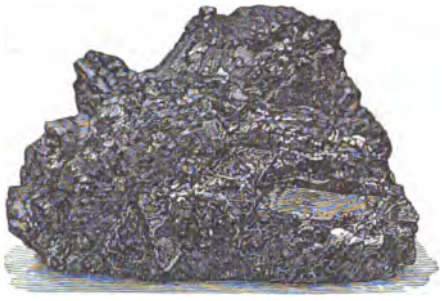


FIG. 1.

was broken up and distributed among several parties interested in the find, and as it was friable, much of it was lost in this manner. About the first of December, 1885, a third fragment was picked up by Mr. Christian in a pool of still water only about fifteen or

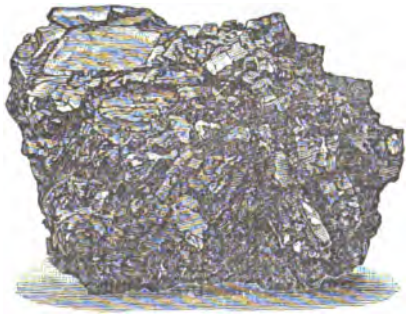


FIG. 2.

twenty feet from where he had found the other. It weighs 535 grams (about 17 oz.), is all broken except one side which is altered to limonite and has no visible trace of unaltered crust. Its measurements are eighty-eight mm., fifty-seven mm. and forty-six mm. The total amount found thus far in the three pieces is

probably twenty-six or twenty-seven pounds. Both of these latter pieces were found in water and had a coating of rust or earthy matter similar to that found on "kidneys" of ore, which was removed easily with the hands or by washing."

The iron is octahedral and made up of crystalline blocks of plessite and hamacite, irregular in shape, brittle, having rounded ends and cleaving readily. Between these are also thin, springy and flexible folia or plates of schreibersite, some of which are 6 or 8 mm. square. The latter mineral was also observed in two other small pieces sent to me. Troilite was also observed in these. The original weight of the piece loaned me for description was 275 grams; one small slice of 34.5 grams weight had been removed to show

FIG. 3.

the internal structure, so that the larger piece, fig. 3, now weighs 228.2 grams. The three cuts show the exact size of these pieces, and the markings on the etched surface as well as the octahedral structure on the exterior of the iron have been accurately reproduced by photography direct from the iron. (Original size as follows: length, 66 mm; width, 40.5 mm; height, 33.5 mm.) The exact date of the fall is not known, and the surface where not cracked off is altered to limonite to a depth of 2 mm. It belongs to the Grobe lamillæ of the new classification of Dr. A. Brezina. The Sevier Co., and Cocke Co., Tenn., and the Arva irons nearest approach it in structure.

The following analysis was kindly made by Mr. J. B. Mackintosh, E. M., of the School of Mines, New York:—

Iron	91.56
Phosphorus	0.13
Nickel and cobalt by difference	8.31
	100.00

The specific gravity of the figured mass is 7.344: that of the small mass.

The iron does not show any Widmannstätten figures, the crystalline structure being really brought out in relief by the schreibersite between the crystalline surfaces. Since the iron was scattered so much in small pieces, we may expect to see them turn up as a number of different falls, but the coarsely crystalline structure, and the broken appearance of the pieces, which are characteristic of this fall, will at once identify them.

The late Judge M. J. Ferguson, while residing at Louisa, Ky., communicated to Mr. S. Floyd Hoard, that one summer about five years ago, at about one A. M., he witnessed a meteor of wonderful brilliancy falling in the direction of the spot where these fragments have since been found: and that he predicted at the time that one would probably be found in that vicinity. The windows facing that way were open, and the curtains drawn back. The light was as brilliant as noonday, and of sufficient duration for him to step to the window and see the meteorite as he thought a short distance away, and surely within the limits of Wayne county.

There is, therefore, a strong probability that the pieces now being described are fragments of the identical meteorite which startled Judge Ferguson on that night. The fact that these masses of meteoric iron were found in water, and that all the branches of the creeks in this county are subject to strong floods of a few hours duration, but sufficient to float logs while they last, may account for the finding of these three pieces, evidently fragments of one piece of very friable iron, scattered as they were, and also for the oxidation of the crust of the iron, which might have remained intact for a much longer period, had the meteorite buried itself in the earth. Of the twenty-six or twenty-seven pounds which were found, only about two pounds have been preserved. I am under obligations to Major Delafield Du Bois, Mr. S. Floyd Hoard and Dr. Jno. N. Tilden for information, carefully and laboriously obtained.

NOTES ON A REMARKABLE COLLECTION OF ROUGH DIAMONDS.

By GEORGE F. KUNZ, New York, N. Y.

AMONG a collection of rough diamond-crystals now on exhibition at Messrs. Tiffany & Co.'s, New York, are a few worthy of special mention. The feature of the collection is that it is made up of material regardless of the price of the crystals. Mineral cabinets usually contain only diamond crystals that have little commercial value; hence many crystals exhibiting the finest and most unique forms never leave the paper, except to go to the cutter. The really fine material is seldom examined by the practical mineralogist. If he wishes to purchase, he calls for the paper of material that he can afford to select from in the hope that it may contain something of interest to him. The collection was formed by one of the largest dealers in rough diamonds in the world, who is also financially interested in South African diamond-mining. With his facilities and capital, he could select the best crystals, regardless of value, for if he lost enthusiasm the only sacrifice would be the interest of the money invested by him even if he could not further realize on them as mineralogical specimens.

There is also a splendid suite, representing most of the South

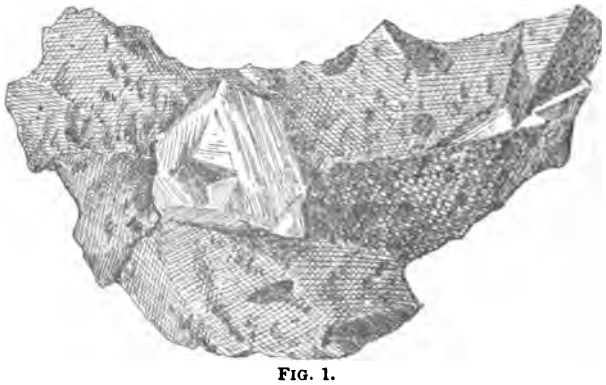


FIG. 1.

African occurrences. The rock is what is commonly called "blue stuff" and crops out across the "black shale." It is a true conglomerate, formed of an altered enstatite, and is chiefly a hydrated silicate of magnesia. All through this apparently pasty mass angular fragments of the black carbonaceous shale, and those fine

large-sized garnets which sell as "Rubin du Cap" in Paris, are found. A very interesting associate is the chromium diopside (euklogite), a variety of pyroxene, of which there is a remarkable specimen 75 mm., 48 mm., 35 mm. This form, usually found in small pieces not over 20 mm. long, is of a rich dark green color occurring darker here than at any other locality where it is found in gem form.

Vaalite, a hydrated mica, is also visible in a variety of forms in most of this series of specimens.

No. 4 (fig. 1) is of unusual interest. It is a fragment of a large yellowish octahedral diamond, about 30 carats in weight, and measuring 24 mm. and 22 mm. respectively, on different octahedral faces. It is 9 mm. thick on one side and 5 mm. on another. Before it was broken the crystal probably weighed from 70 to 80

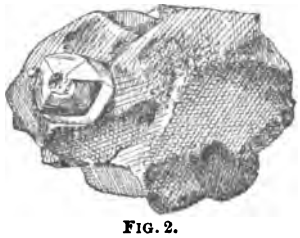


FIG. 2.

carats at least. The fact that the broken side of the crystal is imbedded in the rock clearly shows that the latter is a secondary formation. (Fig. 2 is a diamond in the river conglomerate.)

No. 83 is a $1\frac{4}{32}$ carats fragment measuring 5 mm. by 2 mm. of a whitish diamond. On its cleavage face a small group of cubes of iron pyrites is deposited, also a secondary formation, since it is partly on a cleavage-surface, and does not penetrate the stone.

No. 82 has some interest also. It is a dirty-white, irregular crystal, measuring 9mm. by 5mm. by 5mm., weighing $1\frac{5}{32}$ carats, and deeply pitted, apparently by pressing against the surrounding matrix during formation. Three lots, embracing 20 specimens in all, are well worthy of inspection, as examples of the variety of diamond called "extrême dureté" by the French (*apparently a distinct form of the diamond*). This "hard round-bort" (fig. 3) is often called the "rolled diamond;" a palpable misnomer, since the diamond cannot be rolled. There is nothing in nature hard enough to abrade

FIG. 3.

it except the diamond itself, and this is never found in sufficient quantity. Moreover, the form under consideration is quite uncommon and so excessively hard (see Science, Vol. III, No. 69, May 1884) that it could never be abraded under any natural circumstances, not even with an entire pothole of diamonds, a very unlikely occurrence. It requires 100 days to put a slight polish on a surface 5 mm. square. For instance, "The Kohinoor (with 2000 square mm. of surface) was *cut* in 38 days of 12 hours each, making a total of 456 hours, while it took 1000 hours or nearly twice as much time, to *polish* the 5 mm. surface mentioned above. The wheel (14 inches in diameter) had travelled over 75000 miles, revolved 2800 times per minute, about the highest rate of speed used in diamond-polishing, which would make the resistance at the very least 100 times as great. (See Am. Journ. of Science, July, 1885.)

This form is made up of a multiplicity of twinnings of cubes or radiating agglomerations of cubes. The roughness is evidently due to the fact that the cube face in nearly all diamonds is indistinct, which was characteristic of all cases observed here.

At times, instead of twinning, cubes have been noted that were made up of an apparent fibrous grouping, resembling a round ball, but really made up of a bunching of cubes. This is the case also,

FIG. 4.

in some distorted forms without this ball-like appearance; one specimen resembles a piece of putty after compressing between the fingers, one side being entirely flattened and the other somewhat convex (fig. 4).

Another interesting specimen is a piece of this hard round bort, (fig. 5) with a perfect octahedron of crystallized diamond penetrating (?) and projecting above the mass, showing that the two forms have crystallized under different conditions; also two broken masses of the same, both of which reveal a structure radiating from the centre of the mass (fig. 6). As none of these have been observed in South Africa, so far as I can learn after a wide inquiry, it seems probable that both this *hard form and the cube form of diamond are peculiar to Brazil.*

FIG. 5.

FIG. 6.

The most beautiful inclusions are in lot 26. Among others are two octahedrons and two hexoctahedrons, all white, weighing about $\frac{3}{4}$ carats each, and measuring 3 mm. in diameter, which contain large spots of a rich aurelian red inclusion from .5 to 2 mm. in size (perhaps red oxide of iron?) In addition to this these stones also

contain black carbon inclusions, which, contrasted with the white stone and the brilliant red, present a beautiful appearance. It is, in fact, one of the most beautiful of included-mineral specimens. No. 34 is a much flattened and distorted dodecahedron, 13 mm. by 8 mm., by 3 mm. Fully one-half of the whole centre and of one side is filled with a curious, broken, almost dendritic mass of carbon, which allows the light to pass through it in many places.

In lot 31 there are 35 crystals varying in weight from ¼ to 3 carats, all dodecahedrons with curved faces, which are often irregular and broken. Nearly all of them are brown, and contain carbonaceous inclusions. The most remarkable one, however, is a flat (7 mm. by 2 mm.) crystal, almost entirely filled with a black inclusion, in three triangular divisions with interspaces of nearly equal width (fig. 7). This stone, if polished, would make a wonderful clover-leaf diamond, similar to those in the Jardin-des-Plantes and at Munich.

FIG. 7.

FIG. 8.

No. 50 is a beautiful, white spinel-twin, $1\frac{12}{32}$ carats in weight, 5mm. on each triangle, and 1mm. thick, with a round, black inclusion, occupying all the centre of the stone; and is a fine gem uncut (fig. 8) also a series of white spinel-twins fig. 8*a*.

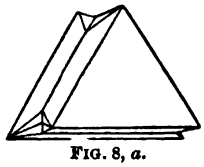


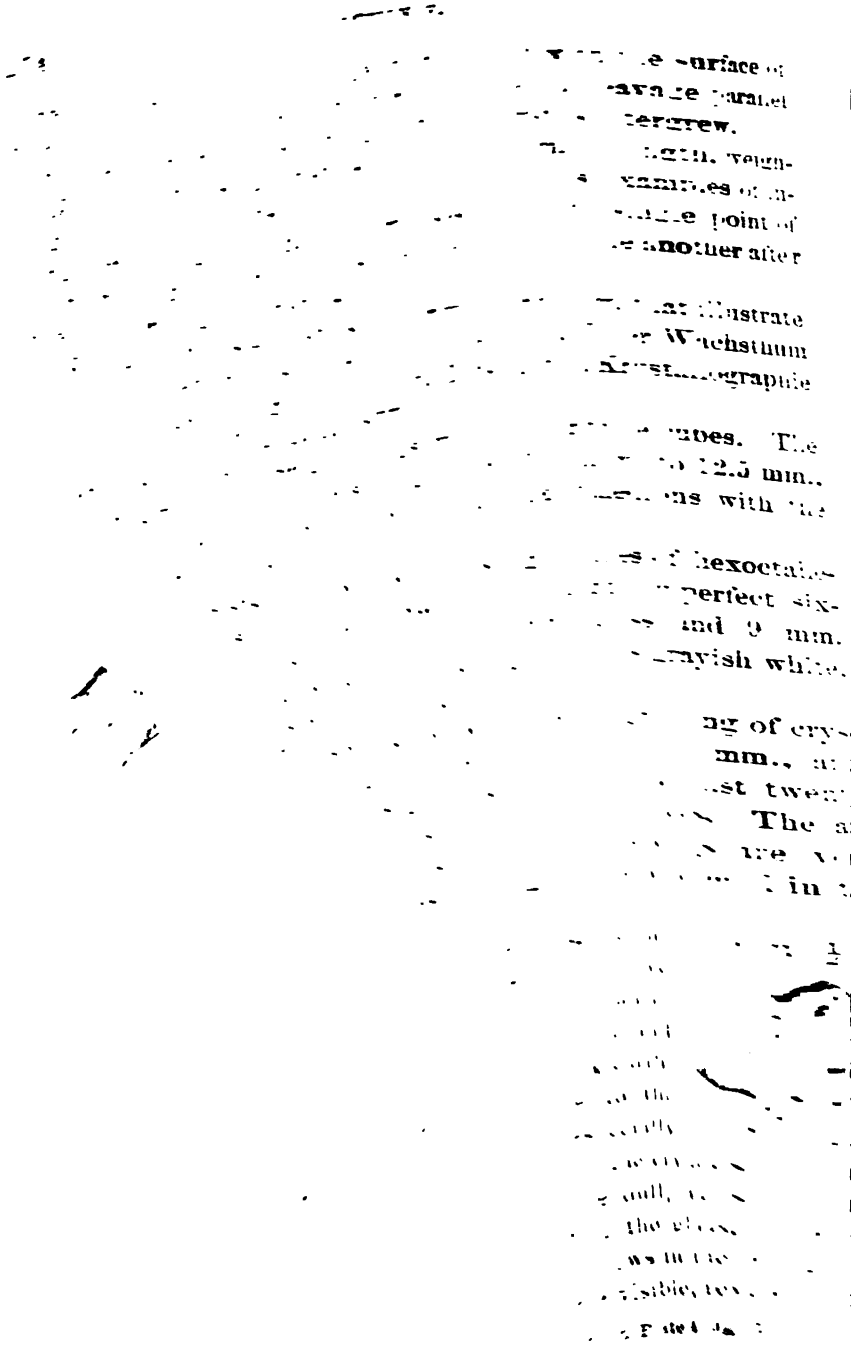
FIG. 8, *a*.

In lot 58 there are five examples of accidental intergrowths of pure white octahedrons. One of 6 mm. (fig. 9) has a small crystal (2 mm.) projecting from the side, and the other four representing the same type, only less distinctly formed, show very interesting groupings of two crystals, one having a fine penetration octahedron (fig. 10).

FIG. 9.

No. 59 (fig. 10) is a fine white octahedral crystal (8 mm.) from which one face of the octahedron has been removed by cleaving. After this plate was removed an inner crystal dropped out. This inner crystal (2.25 mm.) was enclosed at an angle directly opposite to that of the plane of cleavage, and as several of the faces show compression, it was probably formed simultaneously with the larger crystal. And what is more interesting, one point of the octahedron has been broken at a carbonaceous inclosure in such a manner as to leave a small part of it in the larger crystal. This can be readily seen with the glass and appears to be a polished cube

FIG. 10.



inner crystal which is white and transparent. The outer layer is gray and mixed with impurities, and there was evidently a lack of material to cover the faces completely over, so that the surface was left rough, but with a sharp and well defined crystalline form.

In No. 14 there are two octahedrons (6 mm. to 7 mm.) having a very opaque, gray crust, yet transparent internally. If this crust were removed, as is often done in diamond cleaving, octahedrons quite clear, and perhaps more than one-half the weight of the original crystals, would remain.

Among the white crystals is a suite of seven octahedrons all about 14 mm. in size. This lot weighs $90\frac{8}{32}$ carats; and some of them are almost ideal crystals in respect to form and polish of the faces. A few show slightly the development of hexoctahedron or tetrahexahedron, and one in particular has an unequal development of the hexoctahedron so as to suggest a reëntrant angle. The fine polish on the crystals is also somewhat enhanced and

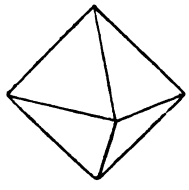


FIG. 13.

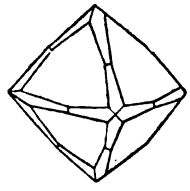


FIG. 14.

beautified by shallow triangular depressions. Lot No. 2 presents what seems to be a rhombic dodecahedron, but in reality is an octahedron with triangular octahedral faces, so raised by unequal growth as to resemble the dodecahedron, and covered with deep striations parallel to the intersection of the octahedral and dodecahedral faces. This crystal is white, transparent, weighs $11\frac{27}{32}$ carats and measures 13 mm. by 10 mm.

To appreciate fully the beauty of a natural diamond crystal, one must examine such specimens as those in lot No. 6, containing 15 crystals from 3 mm. to 5 mm. across and lot No. 7, containing 58 crystals, weighing in the aggregate $12\frac{26}{32}$ carats, and from 2 mm. to 3 mm. across. There are some crystals of such perfect whiteness as to rival those from Brazil, and are the highest type of color from the Cape. They are so resplendent that they refract light almost like cut diamonds. Here also we find the faces of the hexoctahedron and tetrahexahedron, and hexoctahedron and octahedron combined (figs. 13-14).

face, or polished cubic cleavage started by a flaw on the surface of the small crystal. It is, however, more likely a cleavage parallel with the large crystal, showing that both crystals intergrew.

No. 61 contains 22 crystals from 8 to 9 mm. in length, weighing from ¼ to 3 carats each, which afford various examples of intergrowth and grouping, in a few cases with only a single point of contact. Again, octahedrons are piled on top of one another after the manner of gold crystals.

No. 62 contains 4 crystals, either white or yellow, that illustrate very aptly the form described by J. Hirschwald, Ueber Wachsthum und Zwillungsbildung am Diamant, Zeitschrift für Krystallographie Vol. 1, plate VIII, Fig. 1, 1877.

At first glance these groupings would appear to be cubes. The largest is 7 mm., the others range from 3.5 (yellow) to 12.5 mm., and are a combination of the rounded hexoctahedrons with the polished octahedron.

No. 64 consists of two very interesting bunches of hexoctahedrons, forming a rosette or a remarkably perfect six-pointed star (fig. 11), 12 mm. across and 9 mm. thick. The color of this larger group is grayish white, but the smaller one is pure white.

FIG. 11.

No. 65[1] displays a very remarkable grouping of crystals, measuring 19 mm. by 15 mm. by 5 mm., and weighing 10$\frac{17}{32}$ carats. This group is made up of at least twenty hexoctahedrons, showing the simple octahedral faces. The arrangement is apparently confused, yet the markings are very symmetrical on the whole mass proving that they formed in the same orientation (fig. 12).

Lot 15 includes six octahedral crystals, weighing from ½ to 1 carat, and 3 mm. to 2 in diameter, that deserve notice from their rough, granulated appearance, as if hollows had been eaten in them by acid, and afterwards filled in with some grayish black earth. These crystals bear a strong resemblance to the form of magnetite that occurs in chlorite, especially in Harford Co., Md., in which the edges of the crystals are very sharp and well defined though the faces are dull, as is the case with these crystals. On examination with the glass, however, it is readily perceived that these minute hollows in the rough surface are really smooth, and bright spots are visible, revealing an-

FIG. 12.

[1] Von Baumhauer sur la crystallization du diamant, Plate 4, fig. 1.

inner crystal which is white and transparent. The outer layer is gray and mixed with impurities, and there was evidently a lack of material to cover the faces completely over, so that the surface was left rough, but with a sharp and well defined crystalline form.

In No. 14 there are two octahedrons (6 mm. to 7 mm.) having a very opaque, gray crust, yet transparent internally. If this crust were removed, as is often done in diamond cleaving, octahedrons quite clear, and perhaps more than one-half the weight of the original crystals, would remain.

Among the white crystals is a suite of seven octahedrons all about 14 mm. in size. This lot weighs $90\frac{8}{32}$ carats; and some of them are almost ideal crystals in respect to form and polish of the faces. A few show slightly the development of hexoctahedron or tetrahexahedron, and one in particular has an unequal development of the hexoctahedron so as to suggest a reëntrant angle. The fine polish on the crystals is also somewhat enhanced and

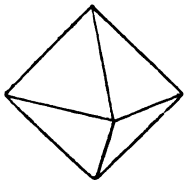


FIG. 13.

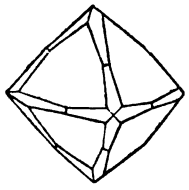


FIG. 14.

beautified by shallow triangular depressions. Lot No. 2 presents what seems to be a rhombic dodecahedron, but in reality is an octahedron with triangular octahedral faces, so raised by unequal growth as to resemble the dodecahedron, and covered with deep striations parallel to the intersection of the octahedral and dodecahedral faces. This crystal is white, transparent, weighs $11\frac{17}{32}$ carats and measures 13 mm. by 10 mm.

To appreciate fully the beauty of a natural diamond crystal, one must examine such specimens as those in lot No. 6, containing 15 crystals from 3 mm. to 5 mm. across and lot No. 7, containing 58 crystals, weighing in the aggregate $12\frac{26}{32}$ carats, and from 2 mm. to 3 mm. across. There are some crystals of such perfect whiteness as to rival those from Brazil, and are the highest type of color from the Cape. They are so resplendent that they refract light almost like cut diamonds. Here also we find the faces of the hexoctahedron and tetrahexahedron, and hexoctahedron and octahedron combined (figs. 13-14).

Lot 23 contains four beautiful examples of the octahedron described by Rose, "Ueber die Diamanten," Abh. der König. Akad. d. Wissensch., Berlin, 1876, figure 34; and J. Hirschwald, Ueber Wachsthum und Zwillungsbildung am Diamant, Zeit. für Krystall. Vol. I, No. 2, 1877, figures 4-9, plate 8 (figs. 17-18). In this case the octahedral faces have been built out by unequal growth and are on a raised elevation above the hexoctahedron, which has given the crystal a divided appearance or caused depressions at all of the cube faces. The crystals measure 10 mm. 8.5 mm. and 2

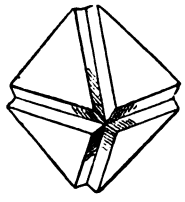


FIG. 17.

are 4 mm. in diameter, and look like the grouping of several octahedrons. One elongated hexoctahedron in lot 69 measures 9 mm., 4 mm. 1.25 mm. A rose colored twinned crystal, and one-half of it showing a curious, step-like structure (fig. 19) in lot 67.

Yellow diamonds are looked upon with disfavor by many and rightly so when we consider the muddy and undecided shades that are termed yellow. But a moment's glance at the series of yellow

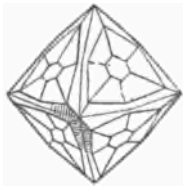


FIG. 18.

FIG. 19.

crystals in this collection cannot fail to lead every one to a more just appreciation of their beauty, and even to give them the preference over the other colors.

Starting with lot No. 8, we have 5 octahedral crystals weighing 3 carats in all and the largest crystal measuring 6 mm. They are ideal crystals in form and have only a slight yellowish tinge, coming, therefore, under the class called second white.

Lot No. 72, contains two fine canary yellow crystals, one elongated 13-10-5 mm. and the other rounded 10mm. They are rounded

hexoctahedrons with a square depression 15 mm. by 1 mm. on one cube face. In this lot as in the preceding the natural polish of the crystals is so remarkable that they might be worn as gems in the rough state.

The color of the 110 pink crystals in the collection varies from a very pale, transparent, and *opalescent* pink to a deep pink or even dark lilac color. They weigh from $\frac{1}{16}$ to 1 carat, and the faces generally observed were the octahedron, the dodecahedron, the tetrahexahedron, and the hexoctahedron. Some are crystallized, as spinel twins. Pink diamonds do not usually crystallize perfectly, nor are they transparent, as will be evident from an examination of this series.

In lot No. 3, there is a fine $7\frac{5}{32}$ carats crystal, measuring 23 mm. on a face and so filled with impurities as to give it a deep brown color. It is interesting from the triangular depressions on its surface, some of which are 2 mm. long and 1 mm. deep. An interesting crystal in lot No. 9 weighing $11\frac{6}{32}$ carats and 14 mm. in diameter, has on its octahedral faces, which are here raised plates almost the size of the crystal face, and on the edges showing the faces of the hexoctahedron, also peculiar triangular depressions.

Some very beautiful brown crystals are found in lot No. 19, one of which, of a rich coffee brown shade, measures 7 mm. on a face and is transparent. Several others in this series are of the same color, and some are spinel twins. Some measure only 1 mm. on a face, but nearly all are of gem value.

No. 78 is a large cleavage of a hexoctahedron, measuring 13, 9 and 5 mm., and weighing $5\frac{1}{8}$ carats. In point of color it is one of the most remarkable stones in the whole collection—a gem as it is—being really of the color of crude petroleum, deep yellowish brown. And what is still more remarkable the stone is as fluorescent as that substance. A gem cut from this stone would be very beautiful. On one of its angles is a round cavity 3 mm. long, 2 mm. wide, and 1.5 mm. deep, which was evidently produced by partial inclusion of some other material. A beautiful, pale green, distorted crystal, transparent and flawless, is in lot No. 11. Its edges are somewhat rounded; it weighs $1\frac{21}{32}$ carats, and measures 4 mm. to 8 mm. in respective lengths. The finest green crystals are in lot No. 75. They are of a very dark copperas shade and measure 2 mm. in diameter. Some of them are entirely made up of trihedral plates. The six stones weigh $\frac{29}{32}$ carats.

The fancy and odd-colored stones are in lots 73, 74, and 79. In lot 73, which contains eighteen stones, there is one rounded crystal measuring 18 mm. by 9 mm. which is transparent and of a faint absinthe green color. In lot 74, which includes five crystals weighing $33\frac{9}{32}$ carats, there is a distorted octahedron, 15 mm. by 17 mm. by 9 mm. The crystals in this series are all smoky green in color, and are all covered with raised and depressed triangular markings; together they form an interesting color-suite.

The cube is represented by an opaque steel-gray crystal, 4 mm. in diameter, resembling the "hard round bort" in lustre. In lot

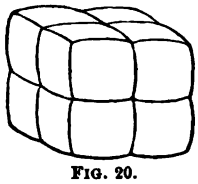


FIG. 20.

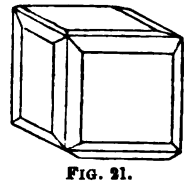


FIG. 21.

FIG. 22.

No. 5, we have a series of four cubes from 2 to 4 mm. in size and weighing $11\frac{9}{32}$ carats. They are of a deep orange, almost chrome yellow. Two of them are made up of eight cubes and united in such a way as to give them the appearance of a bale of cotton, (fig. 20), and the others show the faces of the tetrahexahedron well developed, the cube face being the predominant one however. There is also another lot, No. 76, of somewhat similar color. It contains 16 stones of a deep lemon yellow instead of orange, varying in size from 1 mm. to 5 mm., and weighing $8\frac{29}{32}$ carats together. The color and lustre of these two lots are almost resinous. In lot No. 8, there is a group of cubes with the tetrahexahedron (fig. 21), the color of which is an opaque grayish brown. The group measures 7 by 15 mm., one crystal being 7 mm. square. One of the gems of the collection is the spinel twin of the hexoctahedron (fig. 22). It measures 16.75 m., 18.5 m., 18 m., and is 6 mm. thick. It has depressed faces on both sides representing the octahedral face and both these are beautifully marked with the triangular markings both raised and depressed.

FIG. 23.

No. 55 is a twinned hexoctahedron in which the one-half crystal impenetrates the other. It weighs $2\frac{14}{32}$ carats (fig. 23).[2]

[2] Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 19, 22, 23, are all natural size and drawn from the diamonds.

POST-GLACIAL CHANGES OF LEVEL IN THE BASIN OF LAKE ONTARIO. By G. K. GILBERT, U. S. Geol. Survey, Washington, D. C.

THE GEOLOGY OF ANN ARBOR, MICHIGAN. By Prof. ALEXANDER WINCHELL, State University, Ann Arbor, Mich.

THE MATERIALS OF THE APPALACHIANS. By Prof. E. W. CLAYPOLE, Buchtel College, Akron, Ohio.

THE LOESS AND DRIFT-CLAYS. By Hon. WILLIAM MCADAMS, Alton, Ill.

THE CORNIFEROUS OR UPPER HELDERBERG GROUP OF SCOTT COUNTY, IOWA, AND ROCK ISLAND, ILLINOIS, WITH A LIST OF ITS FOSSILS. By A. S. TIFFANY, Davenport, Iowa.

THE CHEMUNG GROUP AT BURLINGTON, IOWA, WITH A LIST OF ITS FOSSILS. By A. S. TIFFANY, Davenport, Iowa.

SECTION F.

BIOLOGY.

ADDRESS

BY

BURT G. WILDER, M. D.

VICE PRESIDENT, SECTION F.

EDUCATIONAL MUSEUMS OF VERTEBRATES.[1]

Most working biologists are connected with educational institutions and are directly or indirectly interested in collections; yet, in vice-presidential addresses treating of Natural History collections at the British Association in 1864 (Gray,) and 1880, (Günther, 592) little attention is paid to educational museums, and I am not aware that the subject has ever been presented in this Association.[2]

Upon the present occasion, I shall not attempt to cover the whole ground, but shall rather aim to discuss certain questions relating to educational collections which do not appear to have been fully considered heretofore, and which have presented themselves to me during the past year while engaged in a preliminary rearrangement of the vertebrate museum of Cornell University.[3]

Some of my remarks may apply also to invertebrate museums, and indeed, to collections of all objects, artificial as well as natural; but they refer directly to a single branch, partly to insure brevity

[1] In view of the various usage of this term in recent writings it is proper to state that by *Vertebrates* are herein indicated the mammals, birds, reptiles, amphibia, "fishes" and *Branchiostoma* (the lancelet or amphioxus); for convenience, also, this assemblage is sometimes spoken of as a "branch." The Tunicates should be united with the Vertebrates in a more comprehensive group which has been called *Chordata* by Balfour (I, 41; II, 1.) For the understanding of the present address it is not necessary to consider these matters further. The references are to a list at the end.

[2] Less than a page is given to it in the recently published article by the late Professor Jevons (76); the excellent essay by Professor M. J. Roberts refers more directly to medical museums.

[3] I say *preliminary* because of the present limitation of space, and the necessity for accommodating other divisions of the natural history collections in adjacent or even interpolated cases. Hence the fossil representatives of the various groups are now commonly omitted.

and directness, and partly because I think there are peculiar reasons for the existence everywhere of museums consisting, at least in part, of vertebrated animals. Although I have not seen them distinctly stated, these reasons are almost self-evident, and are here named merely to show that the limitation of my subject is due to something more than a personal preference.

With few exceptions, animal food is derived from vertebrates; most of our personal friends and foes are vertebrates, and all domesticated animals fall within the same group. In so far as he is a member of the animal kingdom, man himself is a vertebrate, and all other members of the branch are his relatives, zoological if not genealogical. His bodily appetites and antipathies, his pleasures and his pains, his parts and their operations, his beginning, course and end are comparable with theirs in a degree which impresses one the more, the better the facts are understood. The bulk of what is taught as human physiology is really vertebrate physiology in general, with inferences more or less well established respecting its anthropic modifications. The creations of mythology and superstition are almost invariably vertebrate in their general aspect. Finally, religious writings abound in allusions to alleged denizens of another world, which more or less closely resemble living forms, excepting where wings are associated with arms, a condition of things not yet observed within the vertebrate type. In short, from what we know of man's present constitution and environment, and from what is well nigh universally believed as to his future form, condition and associates, it seems to follow that all kinds and degrees of instruction respecting animals, including man, whether anatomical, physiological, histological, psychological, pathological, or religious,[4] should be based upon some knowledge of vertebrated animals.

Assuming what is now generally conceded, that the inspection of objects is more efficacious than other modes of gaining information; without considering here the extent to which such inspection should be preceded, followed or accompanied by lectures, recitations or the manual examinations of specimens; freely admitting, also, the equal or superior advantages of minerals, plants,

[4] I have previously expressed (Wilder, *70*, p. 446) the belief that the cause of religion would gain from the better acquaintance of its ministers with natural objects and processes. It is encouraging to note an improvement in this respect, but I have yet to hear of a theological school which prescribes or provides practical biological work as a part of its curriculum.

fossils, shells and insects in respect to attractiveness, accessibility, convenience of handling and preservation, and — a consideration of no small importance—the absence or less amount of life-destruction involved, I conclude that *every educational institution of whatever grade should possess, or have ready access to, a museum of vertebrated animals.*[5]

From many vertebrate museums the student or average visitor is apt to carry away, besides the sense of fatigue, impressions which are inadequate or erroneous or, if correct, uncomplimentary; among others the following:

(*a*) Too many specimens are exhibited, and too little can be learned from them; (*b*) there are a great many birds and most of them are pretty; (*c*) there are not so many reptiles and most of them are ugly; (*d*) skeletons are wonderful structures and their preparation must have required much time and skill; (*e*) for aught that indicates their natural attitudes, their mode of progression, their means of attack and defence, the animals might be artificial models of purely imaginary objects; (*f*) vertebrates are apparently mere "skin and bone," or, if any soft parts are shown, they are neither comely nor instructive, and have no obvious relation to the animals from which they are said to have been taken; (*g*) the problems of evolution and other morphological ideas which are presented in all text-books and even in general literature are either so simple as to require no visual elucidation at all, or else so complex and dubious that illustration is impossible.

I believe that the museums of educational institutions would be more useful to students and the public if the following methods were adopted:

(*a*) The exhibition cases should contain only specimens which can interest or instruct the visitor, and all material for research, exchange, laboratory work and practicums[6] should be stored elsewhere.

(*b*) The museum should not only exhibit accurately certain important or interesting *facts*, which may be done by even isolated specimens; it should also, by the orderly and logical collocation of these specimens, illustrate *ideas*, especially such as are com-

[5] This belief was expressed to my students before I had seen Jevons' almost identical remark (64, 76): "I hope the time is not far distant when it will be considered essential for every school to contain a small museum."

[6] A *practicum* here signifies an exercise upon specimens by a class of general students and is limited in character and amount as compared with the work of special students in a laboratory.

monly recognized as fundamental principles and generalizations.

(c) There should not only be special series of embryos, brains, hearts, etc., but such preparations should be associated to a certain extent with the animals to which they belong;[7] for example, in a series of ruminants there should be two or three inflated stomachs illustrating the various modifications of the organ in that group of mammals.

(d) Preparations exhibiting important features should retain as much as possible of the entire animal. For example, among the essential anatomical features of all mammals is the existence of a single aortic arch, on the left side only, whereas in all birds there is a right arch only and in reptiles a right and a left. Undoubtedly, the student can commit these statements to memory; he would probably learn them more readily if he were likewise able to see three preparations of the heart and aorta; but if the left aortic arch could be seen in a familiar mammal, the right in a bird and the two arches together in a reptile, there would be facilitated not merely the acquisition of the facts, but likewise the association of the facts with the groups which they characterize.

(e) When the retention of the entire animal is inconvenient, unless the species is so common that its name alone is enough, a figure, especially a photograph, will insure the desired association; for example, in a series of the skeletons of the hands and feet, especially if physiological relations are to be illustrated, it would rarely be convenient to place the entire animals in close proximity, but figures of them would recall their appearance and mode of life much more readily and vividly than their mere names.

(f) In arranging specimens whose relative rank is well determined, the higher or more complex should be placed above the lower or more generalized. In arranging series, especially of

[7] Nearly twenty years ago the "deficiencies in the present mode of arranging public collections" were commented upon by the late Professor Agassiz (10): "The mere accumulation in systematic order of select specimens from given classes, families, genera, etc., has after all little intellectual value and does not in any way represent the progress of our investigations. Zoölogy, comparative anatomy, embryology and paleontology are only parts of one great system, combining under different heads our knowledge of the affinities, the structure, the mode of growth and the order of succession of animals, through all times and in their past and present distribution upon the surface of the globe. In order to represent these different aspects of the subject in their connection with one another, it is necessary to combine whole specimens of living animals, anatomical preparations, embryological series and fossil remains in the same case or on the same shelf, in such intelligent relation that they shall illustrate each order, instead of isolating them in separate museums [or separate parts of the same] as is usually done."

embryos, having a logical sequence, those which are to be examined first should, it seems to me, be placed at the left so that, as on a printed page, the eye may pass from left to right.

(*g*) Every specimen should teach something, but, as a rule, *one thing only;* prominence to that feature being insured by either the mode of preparation or mounting or arrangement, or by labels or descriptions. "One thing at a time and that done well."

(*h*) As a corollary to the foregoing, it follows that the illustration of several different facts or ideas in different parts of the museum may necessitate the multiplication of the same form to an unexpected degree. For example, the Australian duck-bill or platypus (*Ornithorhynchus paradoxus*) is comparatively rare in museums, yet nearly a dozen might find appropriate places as follows: 1. As one of the small group of Monotremata in a complete series of mammals; 2. As a sub-class representative in the class synopsis; 3. As a part of the Australasian fauna; 4. As one of the aquatic non-fishes; 5. As a burrower; 6. With the beaver and perhaps some others, with spatula-like tails; 7. As an oviparous mammal with meroblastic ova; 8. As illustrating ectal differences of sex, the male only having the crural spur and gland; 9–12. As preparations of the skeleton, muscles, brain, heart and reproductive organs. In addition to the above named examples of adults, a limit can hardly be set to the desirable fulness of a series of embryos of this remarkable form. Again, in a museum of only moderate size a sea-snake should occur in at least *six* places, viz.: 1. In the class synopsis of the Reptilia; 2. Among the venomous vertebrates; 3. Among the viviparous ¡immammalia; 4. Among the aquatic non-fishes; 5. In a series of tails; 6. As illustrating one of the arguments in favor of the existence of a "sea-serpent." In a more comprehensive museum a sea-snake might be introduced in at least four other places, viz.; 7. In a complete series of all reptiles, or serpents or sea-snakes; 8. As a member of a local fauna; 9. Among anatomical preparations; 10. Among embryological preparations. Whether the six specimens first mentioned should be of one species or of several different species, genera or families, is a point worthy of consideration which cannot be discussed here.

(*i*) With museums, as with other things, quality is more important than quantity, and as a rule, "arrangement is more needed than acquisition."[8] As the efficiency of a regiment is determined, not by the size of its camp or the crowding of its tents, but by the

[8]Nature, May 7, 1885, p. 12.

number of men, healthy, well-equipped and disciplined, that can be mustered for action at a moment's notice, so the usefulness of a museum depends far less upon its extent than upon the number of well-prepared, clearly-labelled and logically-arranged specimens that meet the eye of the visitor.

(*j*) Accessions to a museum for instruction should not commonly occur by chance but be regulated by the will of the curator in accordance with the scope and means of the institution. Formerly, when comparatively few species were known, all that a traveller could obtain, all that a community could offer, might not supply the demand for instructive and curious objects. The zealous and devout curator might fairly regard all accessions as furnishing providential means of greater and wider usefulness and shrink —almost as from impiety—from any loss of such opportunities.

But the conditions are certainly changed, and few museums can ever be expected to contain all kinds of natural objects. And even if they could, why should the chance of acquiring a specimen however peculiar and unexpected, be viewed with any special consideration? In other affairs an opportunity may be for good or for ill; a leading or a misleading; it may be an occasion to be embraced or a temptation to be shunned. We decide to welcome or resist according to circumstances, and feel assured, notwithstanding mistakes, that not every tide, "taken at the flood, leads on to fortune." So far then from taking all that is offered merely because it is easily or cheaply acquired, the curator will practise a true economy in paying liberally for what he does want rather than in accepting what he does not want as a gift. In some contingencies indeed, to modify slightly the epigram of Mr. Higgins, it may be the chief duty of the curator of a museum to keep things out of it. As the wisest physicians are those who prescribe the least physic, so, in equal contravention of instinct, popular belief and etymology, the best museum curator although always, at least indirectly, a collector as well, practises the habits of discrimination, rejection and even elimination.

This brings up two subjects, the principles of selection and the methods of elimination. The second, being simpler, may be taken first.

(*k*) Superfluous specimens may be (1) stored in small space; (2) converted into anatomical preparations to illustrate special points; (3) issued to students; (4) distributed to individuals or institutions elsewhere, as was done a few years ago by the Museum

of Comparative Zoology; (5) destroyed, preferably by fire. Unacceptable as appears this last resort it is sometimes the only way in which the curator can escape being overwhelmed with care and expense. It should never be forgotten that museums are made for man and not man for museums.

As to the principles of selection, some are of general application, while others depend upon the scope of the museum and the views of the curator.

(*l*) The usefulness of a specimen is to be measured not by its rarity or cost but by the degree in which it embodies and displays important facts or ideas. For example, of the three living Dipnoan genera, the South American *Lepidosiren* is so rare as to be practically unattainable at any price, and *Ceratodus*, though common in certain Australian rivers, costs twenty dollars or more by the time it reaches us. But the Egyptian *Protopterus* may be had for five to ten dollars, and though smaller and less striking in appearance answers just as well as a representative of an interesting group.

(*m*) Many specimens should be not merely labelled but accompanied by figures and explanations. Three important ends are thereby secured, viz.:

(1) The naturally obvious points are more forcibly or completely impressed by this "triple alliance of object,[9] drawing and description," appealing respectively, at least potentially, to the mind through the three channels of vision, touch and hearing; (2) with many anatomical preparations, with embryos and with specimens which are either very small or delicate or which have become distorted or are otherwise imperfect, even the most essential features may be inadequately displayed; a figure, especially if accompanied by an outline diagram, may call attention promptly and clearly to the points which it is intended to illustrate; (3) when specimens have been figured or described, the association with them of the figures and descriptions, or at least of references to the latter, indicates in some degree the kind and amount of work which has been accomplished, and facilitates the verification of observations and interpretations of structure.

The curator of the (vertebrate) museum of an educational institution is commonly also the professor of physiology and zoology, and the collections are arranged, according to his general bias, so as to present one or more of three series, more or less complete:

[9] A happy phrase used by M'Alpine.

the *physiological* or teleological, the *systematic* or taxonomic, and the *geographical.*

Without denying the usefulness of such series, at least under certain exceptional conditions, I think that the same specimens, representing an equal amount of money or time, would have a higher educational value if divided among a considerable number of special series, each illustrating some morphological or teleological principle.

Before discussing the larger subject, the character, scope and arrangement of natural series, let me mention a few which, in contradistinction, may be called *artificial series*, but which have a real and even considerable importance.

(*a*) Animals which have been exterminated by man, or for any cause have become extinct within historic time: *e. g.*, the auk, rhytina, dodo, epiornis, etc.

(*b*) Those which furnish us with food, medicines, weapons, clothing or materials for habitation.

(*c*) Animals named in Shakspeare's writings.

(*d*) Figures of mythical and fabulous creatures accompanied by the actual forms which are supposed to have suggested them, or by pictures or models of them. Under this head, for the present, at least, would come the hitherto untaken "sea-serpent."

(*e*) Animals held sacred or in special respect in any part of the world, as, *e. g.*, the ichneumon, cat, crocodile, scarabæus, stork, etc.

(*f*) Forms named, or supposed to be alluded to, in the Scriptures. For example, it is probable that few persons have any correct idea of the "coney" (*Hyrax*) and not all museums possess specimens or preparations of it.

Coming now to the natural series, I believe that *the foundation and starting point of a vertebrate museum should be a synopsis of the entire branch.*[10]

This branch-synopsis should embrace two sets of specimens:

(*a*) Entire representatives of the classes, one of each.

(*b*) Preparations exhibiting the persistence of the vertebrate plan or idea under great diversity of form, habit and structural detail.

The vertebrate synopsis case should be conspicuous, well-lighted, and ample, but not larger than can be covered by the eye without changing station. The specimens should be of moderate size, as

[10] This subject was presented to the American Society of Naturalists in 1883; (Wilder *55.*)

perfect as possible, fully-labelled and accompanied with figures and explanations.

From the foregoing propositions I anticipate no dissent, but upon the following details differences of opinion are inevitable.

For example, scarcely two original workers in vertebrate comparative anatomy agree respecting the number and names of the primary divisions of the branch which should be included in the synopsis. Probably the accompanying list represents the extreme of length; the other extreme would be in Huxley's "Mammalia, Sauropsida and Ichthyopsida." The groups here named differ in scope and may not be coördinate, but are commonly admitted to be real and natural.[11]

List of (provisional) vertebrate classes, and of forms representing them, as they may be arranged in the Branch Synopsis Case.

BIRDS.	MAMMALIA.
Pigeon.	Opossum (?).
REPTILIA.	AMPHIBIA.
Lizard (*Sphenodon*).	Salamander (*Amblystoma*).
TELEOSTEI.	DIPNOA.
Trout.	*Protopterus*.
GANOIDS.	HOLOCEPHALA.
Garpike (*Lepidosteus*).	*Chimæra*.
ELASMOBRANCHS.	MARSIPOBRANCHS.
Cestracion or *Acanthias*.	*Petromyzon* (lamprey eel).
TUNICATES.	LEPTOCARDIA.
Specimens and models.	*Branchiostoma* (with model).

[11] Whatever may be decided respecting the Ganoids and Holocephala, to regard the Dipnoa as a mere order of Ganoids seems to me a piece of "scientific *gaucherie*," comparable only with the union of Ganoids and Elasmobranchs as "Palæichthyes." Pending the determination of the relationship of the Tunicates to the vertebrates, the former should be included in this case. Colored glass models of *Salpa* may be had of Blaschka in Dresden.

In the relative positions of the classes, beyond placing mammals and birds at the top and Leptocardia, Marsipobranchs and Elasmobranchs at the bottom, no arrangement can be regarded as strictly natural or likely to meet the approval of all. The groups might be arranged in three vertical rows of four each, but the sequence in either of the rows might imply some incorrect or unproven relationship. Hence it should be distinctly stated that the case is not intended to indicate either degrees of affinity or lines of descent, but merely to represent the various divisions of the branch within the smallest compass.[12]

With most of the groups there is room for considerable difference of opinion as to the genus and species of the representative. The following conditions are to be satisfied as far as possible: generalized rather than specialized structure; moderate size and cost; familiarity; the specimens should be stuffed rather than in alcohol, and, excepting the bird, placed horizontally.

For the Teleosts almost any abdominal fish would answer. The lizard should not have an excessively long tail, and the objection to Sphenodon is its comparative cost; most of the ordinary salamanders are small, and unless one of the larger Amblystomas could be had, the Amphibia could be represented by Cryptobranchus (Menopoma) or Megalobatrachus or even Necturus.

On some accounts the mammals might well be represented by one of the Insectivora, but, notwithstanding the generalized character of that group as a whole, all of the living forms are objectionably specialized in some respect.

From R. Weisker, in Leipzig, may be had an admirable wax, colored model of *Branchiostoma*, 61 cm. long, for about twenty-five dollars; also a series of embryonic stages and transections.

Accompanying each class representative should be preparations exhibiting the essential branch character, viz.:

(*a*) A transection of the entire body at or near the heart.

(*b*) A skeletal segment including the *axon* or skeletal axis and the arches inclosing the neural and hæmal canals or cavities.

(*c*) A hemisection of the skeleton showing the variation in size

[12] Believers in evolution may legitimately indicate their suppositions as to the probable line of human descent by phylums or phylogenetic diagrams. The inevitably misleading effect of representing any other than purely dichotomous branchings upon a plane surface may be avoided by employing, in place of names, actual representatives of the several groups, and bringing them into their presumed, genetic, relative positions by supporting them not upon fixed shelves but upon movable brackets.

of the neural and hæmal canals in the different regions of the body.

(*d*) A dissection, for the most part a hemisection, of the entire body, showing the neuron (neural axis), the unconvoluted portions of the enteron (alimentary axis), the heart and aorta.[13]

Each preparation should be made clear by descriptions and by figures on which the chief parts are distinctly outlined and named. If these organs are colored, their relations will be much more easily recognized.

Should the preparations just named be made from examples of the same genus or species as the entire class-representative, or from members of distinct orders? Something may be said on either side. When a certain important fact or idea is to be demonstrated any other features likely to distract the attention are undesirable. Hence some advantage is presented by the unigeneric Leptocardia, and by the Dipnoa, Holocephala and Marsipobranchs, where the choice may be limited naturally or by the rarity and cost of certain species. On the other hand, it is to be remembered that the object of the branch-synopsis is two-fold: first to exemplify a certain arrangement of organs; second, to show that this arrangement prevails throughout a large number of otherwise dissimilar forms. There is to be set forth not alone a particular type of structure, and not alone an assemblage of forms, but the fact that these apparently heterogeneous animals have a common structural pattern. Not unity alone, nor variety alone, but unity in variety.

From this more comprehensive point of view, I conclude (*a*) that, so far as possible, the several preparations should be made from representatives of as many orders of the class; (*b*) that in choosing the forms the conditions already enumerated be ob-

[13] The terms *axon*, *neuron* and *enteron* were employed by me in 1884 (*56*, Aug. 2, 1884, p. 113) not only as brief, mononymic equivalents for polyonyms or longer terms, but also because they designate, respectively, the three axes in their entirety and without reference to histological composition. *Enteron* designates the whole of the alimentary canal. *Neuron* includes both the myel (spinal cord) and the encephal (brain) and is thus the equivalent of *myelencephal*, *cerebrospinal axis* and *central nervous system*. *Axon* means the skeletal axis, whether it be a membranous tube, a cartilaginous rod (notochord), or a series of vertebral centrums. Of the commonly employed synonyms, *spine* is ambiguous, and *vertebral column* incorrect because it includes not only the centrums but accessory parts. Strictly speaking they are not new words but the natural substantives of the adjectives *axial*, *neural* and *enteric*, the last two occurring together in *neurenteric*. The reasons for preferring *myel* (adj. *myelic*) and *encephal* to *myelon* and *encephalon* are given in my papers (*63*, 354; *64*, 12).

served; (c) that recognition of the forms be facilitated not only by figures of the entire animals, but, in the preparations of the soft parts, by retaining the skin, and the entire cephalic (anterior) region of the body. For example, with the reptiles, if the class representative were Sphenodon, the skeletal segment might be from a large serpent, the hemisected skeleton from a small alligator, the hemisection of the entire body from an ordinary lizard, and the transection from a turtle, the head and cephalic half of the body serving to identify it in addition to the "shell."

Each class division of the branch-synopsis should have a label bearing not only the preferred name of the class, but its synonyms and the common names of its more widely known members. For example, if *Amphibia* be preferred as the class name, *Batrachia* may be added as a synonym, and the constituency of the class indicated by the common names *frogs*, *toads*, *tree-toads*, *salamanders*, *newts*, *cœcilians*.

It would be well to state the number of known species in each class, living and extinct.

Whether, in addition to the structural feature illustrated by the preparations mentioned, there should be models or figures of the developmental features of vertebrates, the formation of the neural laminæ and canal, and whether extinct orders should be merely named. or represented by figures, models or specimens, I shall not undertake to discuss on this occasion.

Theoretically, each class should be more fully presented in a class-synopsis, and on some accounts it would be easier to commence with one of the lower groups embracing a small number of species. But the considerations upon which the vertebrates are selected before the other branches apply equally to the primary illustration of the mammalian class, notwithstanding the conditions are much more complex and difficult to observe.

As at least an approximation to what is desirable, permit me to enumerate the specimens now constituting the mammalian class-synopsis at Cornell University.

A. Entire examples of groups (orders):

Primates: Monkey, *Cercopithecus*. Carnivora: raccoon, *Procyon;* seal, *Phoca*. Ungulata: musk-deer, *Tragulus*. Sirenia: dugong (fœtus). Cetacea: porpoise and model of whale. Cheiroptera: bat, *Pteropus*. Insectivora: mole, *Talpa;* hedgehog, *Erinaceus*. Rodentia: squirrel, *Sciurus*. Edentata: sloth, *Bradypus;*

armadillo. Hyracoidea: coney, *Hyrax.* Proboscidea: a small model of the elephant. Marsupialia: opossum, *Didelphys;* small kangaroo, *Hypsiprymnus.* Monotremata: duck-bill, *Ornithorhynchus;* echidna.

The above named mammalian representatives occupy the upper and lower portions of the case. Most of them display the *hair* which is a character of the class. The shelves more nearly opposite the eye bear preparations illustrating structural characters.

B. The preparations are as follows:

1. Monkey, showing the mammary glands. 2. Kitten, dissected to show the single aortic arch turning toward the left. 3. Skull of a porpoise showing the two occipital condyles. (The fact that the basioccipital enters into their composition is to be more fully indicated upon a special preparation.) 4. Preparation and enlarged model of the three bones in the middle ear. 5. Model of a non-nucleated, circular, red blood-corpuscle. 6. Heart of a dog distended with alcohol and transected to show the two auricles and two ventricles; model of the heart of a dugong. 7. Kitten, opened from the left side and all the viscera removed, leaving the diaphragm as the prominent feature of the preparation. 8. Several brains showing the callosum or great cerebral commissure. 9. Parts of skeletons showing the presence of seven cervical vertebræ irrespective of the length of the neck. 10. Preparation and model of the lungs. The formation of the allantois and several other features of embryonic development or adult structure might be illustrated by other preparations, but the foregoing will serve the purpose of the present discussion.

I refrain from saying that these preparations illustrate *the* class characters, purposely and for three reasons: first, some matters of fact are as yet undetermined; second, for lack of material or time, certain preparations have not been completed; third, I am in doubt as to the best way of indicating the fact that *what are commonly enumerated as class characters are by no means of the same grade.*

For example, all mammals have mammary glands (rudimentary in the male) and they are not known among the other vertebrates. The character is *constant* and *peculiar.*

In all mammalia, the heart has four cavities, but this is true likewise in all existing birds and in the crocodilians among reptiles. Hence the presence of a quadrilocular heart, although *constant* is *not peculiar* to the mammals.

Again, while nearly all mammals have seven vertebræ between the skull and the thorax, at least three species have a differen number, and the same number occurs with a few other vertebrates, Hence this character is usual, but neither constant nor peculiar.

There is no sufficient evidence that a callosum or true placenta occurs outside the mammalia, but the latter is certainly not developed in all; and the former, notwithstanding the researches of Flower, has not, I think, been satisfactorily demonstrated with the monotremes and marsupials.

Finally, while the diaphragm is fully developed in mammals alone, it exists in a rudimentary form in certain reptiles and birds, and any generalization on the subject must be carefully guarded.

Without entering further into detail, I trust enough has been said to show that: *of the features commonly enumerated as characterizing the mammalian class, some are constant and peculiar, others are constant but not peculiar; some are peculiar but not constant, and others again are neither constant nor peculiar.*

The neglect to indicate the differences above mentioned in lectures, text-books and museums gives rise to inaccuracy or uncertainty in the minds of students.[14]

In addition to the class-synopses outlined above, any or all of the classes may be displayed more extensively, as means and opportunity permit, by representatives of each family or even genus and species. Since, however, few museums can be expected to contain every species of vertebrate, and since the principles of classification and of geographical and individual variation can be elucidated upon almost any considerable assemblage of species, there is room here for a choice among orders or families in accordance with the special preferences of the professor or curator in charge. For example, I desire that the Museum of Cornell University should contain examples of every species of the class Amphibia and of the family Felidæ.

In their fullest development it may well be that branch and class synopses, such as are outlined above, would rarely be formed excepting in the museums of well-endowed universities; but they may be partially established in even a primary school, and a real demand will sooner or later create a supply of anatomical preparators who can make the needed dissections.

[14] Of course the principles here outlined apply to all characterizations of all kinds of objects, natural and artificial.

As to the cost, the smallest school collections almost invariably contain useless and worse than useless stuffed birds and quadrupeds and alcoholic fishes, the cost of obtaining and preserving which would have supplied such typical forms as lamprey, shark, ray, garpike, opossum and even the rarer protopterus and branchiostoma.

For sound, elementary and fundamental instruction in vertebrate zoölogy, a dozen such examples with a few hearts and brains and a very few skeletons would outvalue a "wilderness" of stuffed birds and a forest of skeletons. The fact that these latter can be purchased from dealers is no good reason why money should be paid or storage room provided for them.

I pass now to the consideration of natural series which are not systematic like the foregoing, but which illustrate morphological or teleological principles and may, therefore, find places in museums of any considerable extent.

Modern science properly rejects the classification of vertebrates into "beasts of the field, birds of the air and fish of the sea;" yet these groupings, with many others (as of climbers, burrowers, etc.), are based upon actual analogies and are, therefore, natural, rather than artificial, and hence worthy of exemplification by special series.

From the educational side there is another reason for grouping together forms which have less structural affinity than external resemblance or analogy. A bat may be mistaken for a bird, a salamander for a lizard, a hedgehog for a small porcupine and a lamprey for an eel, *so long as they are in separate parts of the museum;* but, as twins are more easily distinguished when together, so the essential distinctions of analogous forms become apparent and impressive when simultaneously presented. For example, *rostrated animals*, or those provided with a rostrum or considerable prolongations of the upper jaw, are sometimes mistaken for each other. Of the saw-fishes some are rays (*Pristis*) and others sharks (*Pristophorus*) and both are sometimes confounded with the teleostean sword-fish (*Xiphias*) whose blade has no teeth. In the same series would fall the paddle-fish (*Polyodon*) and shovel-nosed sturgeons (*Scaphyrhynchops*). Another special series would embrace *spinous forms;* globe-fishes; moloch and other lizards; the echidna, tanrec, hedgehog and porcupine among mammals. Still another would include possessors of folds of the skin serving as *parachutes; e. g.*, flying squirrel, the marsupial

petaurist, the galeopithecus, the flying-dragon and the Bornean frog, *Rhacophorus*.

Among physiological series which are rarely found in educational museums are the following:

Hibernating animals, as, *e. g.*, raccoon, marmot, hedgehog, etc.

Animals provided with *scent glands; e. g.*, musk-deer, peccary, skunk and some other carnivora.

Those which are *blind*, or nearly so; *e. g.*, hag-fish, mole, blind-fish of caves, proteus, etc.

Possessors of *prominent tusks;* elephant, deinotherium, walrus, machairodus, narwhal, etc. Accompanying the entire animals or their skulls should be preparations, adequately explained, to show that the tusks of the walrus are canine teeth, those of the elephant incisors, and that the narwhal's, while apparently mesal or azygos, is really one of a pair, the other remaining concealed within the jaw.

Electric animals: *Torpedo*, *Gymnotus*, *Malapterurus*. *Luminous* fishes: *Scopelus*, etc.

Venomous forms, *e. g.*, the rattlesnake and other serpents; the only known venomous teleosts, the half-dozen species of *Thalassophryne* from Central and South America; the two species of *Heloderma*, the only venomous lizards; with these should be preparations of the various kinds of poison apparatus; and, in addition to ordinary labels, there should be explicit statements as to where these dangerous creatures live, and brief accounts of precautions and antidotes.

Time will not permit the discussion of the geographical and geological series of animals alluded to by Professor Agassiz in the passage already quoted. I will merely express my hearty approval of the recommendation which has been made by several writers on museums, that there should always be a special collection to illustrate the *local fauna*. This would not, as a rule, embrace anatomical preparations, or have special reference to affinities or to the more general morphological problems. But it should fully illustrate the appearance of each species by specimens of both sexes and at all marked stages of development and growth; the mode of life, food, enemies and useful or noxious characters should be indicated, with any information likely to benefit or interest the children, farmers, hunters, and fishermen of the neighborhood. A local collection benefits the student in two ways: it

exemplifies the influence of environment and the laws of geographical distribution, and it serves as a pattern for him to follow or improve upon in the future.

In a general museum guide or in the descriptions of each series, attention should be called to the existing deficiencies of the museum, and the graduates and other friends of the institution should be reminded of the opportunities, often peculiar, which they may have for supplying these *desiderata*.

Although more than a quarter of a century has passed since the promulgation of the modern, scientific doctrine respecting the method of creation, although opposition to the general idea of organic evolution is now almost confined to the stubborn and ill-informed, and although its substantial truth is tacitly admitted or openly claimed in nine out of ten of the higher educational institutions of this country, I have yet to hear that any considerable part of a college museum has been specifically devoted to the exhibition of the facts which are described or figured in zoölogical text-books and works upon popular science.

Such a collection should embrace much more than a few ape skeletons hung beside that of man. To avoid the appearance of dogmatism, let me briefly mention the series relating to evolution which have been begun at Cornell University:

A. Simple ontogenetic series, exemplifying the extent of transformation of certain forms, and the rapidity of their occurrence; *e. g.*, preparations or models of Branchiostoma, frog, chick and human embryos.

B. Comparative ontogenetic series, illustrating the resemblance between successive stages of one form and the adult conditions of others; *e. g.*, the tail of the gar-pike (Lepidosteus) which successively resembles those of Protopterus, the sturgeon and the Amia; the branchial apparatus of a salamander like Amblystoma which successively resembles the permanent conditions in Necturus and Cryptobranchus.

C. Generalized, synthetic or intermediate forms or "connecting links;" *e. g.*, archæopteryx; toothed birds; pterodactyls; ceratodus.

D. Presumably degenerated forms; *e. g.*, lamprey, hag-fish, sirenia.

E. Apparently useless or atelic organs and conditions; *e. g.*, the nipples of male mammals; the cæcal appendix of the human intestine.

F. Examples of apparently needless rules and exceptions thereto; *e. g.*, the adherence to the number seven with the cervical vertebræ of mammals, excepting in three species; the persistence of the circular form of the mammalian red-blood corpuscles excepting in the Camelidæ.

G. Human peculiarities, not only as to the skeleton but also the brain, heart and other parts.

H. Human resemblances to mammals in general.

I. Features which unite man with the tailless apes and separate them from other mammals.

J. Transitory human organs and conditions which resemble the permanent organs and conditions of other mammals, especially apes; *e. g.*, the earlier condition of the brain; the presence of a tail; the pharyngeal clefts; the general form of the body and limbs.

K. Human anomalies resembling the normal structures of apes.

L. Anomalies and malformations affecting man and other vertebrates in a similar manner.

M. Evidences of accident and disease among wild animals.

While most of series just named would favor evolution, one embracing absolute peculiarities of the human body looks the other way, and the candid teacher or curator would certainly not refrain from placing the so-called "Difficulties of Darwinism" in visible form before his students and visitors.

A statue of Darwin has recently been dedicated in London with honorable ceremonies. What monument to his memory could be more lasting or appropriate than the formation, in all educational institutions, of collections especially designed to present the facts which he made significant, and the ideas which his knowledge, his industry and his honesty have caused to underlie the intelligent study of nature throughout the world!

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PAPERS READ.

AN OBSERVATION ON THE HYBRIDIZATION AND CROSS-BREEDING OF PLANTS.

By E. LEWIS STURTEVANT, M. D., Director of the State Agricultural Experimental Station, Geneva, N. Y.

GEORG von Martens, in his Gartenbohnen, Ravensburg, 1869, p. 35, under Phaseolus Pardus virescens, the graugrune pantherbohne, says: "I was very much surprised to obtain not less than eight varieties of beans, die incarnatbohne, die dottergelbebohne, die weissebohne, die amethystfarbige zebrabohne, die graugrune pantherbohne, die helle pantherbohne, gelbgefleckte pantherbohne, and the princessinbohne. With more thorough investigation I decided that the zebrabohne was most likely a neighbor which had overrun the bed, but all the others came from the bed, and some, the incarnatbohne and the weissebohne had not been planted in the whole garden." Martens might have expressed surprise that these variations from the seed of the graugrune pantherbohne were all towards named varieties rather than sports or intermediates, but this fact, which frequently appears noted in his book, does not receive attention as being of any importance.

At the New York Agricultural Experiment Station, in 1882, a few oblong beans, slightly flattened sidewise and mottled in two shades of brown, were selected from the yield of the golden cranberry. This selection, planted by itself in 1883, gave eleven distinct forms, many of which can be referred to named varieties, and possibly with a greater acquaintance with varieties all might be so referred; an illustration confirmatory of the results above noted by Martens, and strengthened by a list of similar occurrences with other varieties in 1883 numbering a full score.

This fact of named varieties being produced from seed of other varieties is not confined to the bean family alone. The following list includes similar occurrences noted at the New York Agricultural Experiment Station during the last three years:

Maize.—Seed of one kind sown often produces samples of other

kinds of corn in the crop, and these variations can usually be distinctly referred by name to varieties with which the original seed might have been crossed. Purposely hybridized seed has produced the original parentage without intermediate types, and seed exposed to hybridization during two years with many sorts of corn, has yielded ears of the types of corn with which cross-breeding or hybridization has been effected, without appearance of intermediate forms.

Barley.—April, 1884, one head of cross-bred awnless barley was received from Mr. Horsford, a seed-grower in Vermont. The yield of the twenty-six seed was four distinct sorts of barley; one beardless black, one beardless white, one bearded black and one bearded white. One peculiarity was, that the beardless forms could be referred to *Hordeum trifurcatum*. There were no intermediates in this crop.

Peppers.—In 1882 eleven varieties of peppers were grown; in 1883, nineteen varieties. The pepper plant is extremely variable. The fruit on different plants of the same variety often varies much in shape; on some the fruit is borne erect, on others pendent; certain plants of a variety often mature their fruit much earlier than do others. These facts, as well as direct observation, certify to the ready cross-fertilization, between varieties. Yet, despite this apparent, cross-fertilization, varieties by selection are kept true to name, and almost all or perhaps all of the various "sporting" forms noted by us are found illustrated in Hortus Eystettensis, 1613, a fact which brings the pepper in line with our other illustrations.

Tomato.[1]—In 1882 the French upright tomato was crossed with pollen from the alpha and Livingston's favorite. The produce from the cross-breds was one plant of the French upright, a hundred or more of the common form, and no intermediates. The fruit was all clustered, however, and of one type of bearing. The

[1]Some additional observations of a later date than those given in this paper are as follows:

Melon.—The Christiana melon seed used in 1885 was from two sources. The one seed pure and the crop all on type; the other seed station-grown in 1883 and subjected to a possible cross-fertilization with other varieties; the produce from this seed gave this year fruit mostly of pure Christiana type, but some plants yielded fruit of the early white Japan, long Persian and Hackensack types, and no intermediates. These off-varieties were among the melon varieties of 1883, and by which there was a possibility of the Christiana being crossed through insect agency.

Tomato.—In 1883 the French upright tomato was crossed by the Livingston's favorite, and the crossed seed has been attempted to be grown in purity up to date.

types of the tomato fruit have not as yet been sufficiently studied by us to allow of a judgment upon variability in this respect.

Squash.—In 1883 the perfect gem and vegetable marrow squashes were crossed in both directions. The seed planted in 1884 gave good types of the cocoanut, green-striped bergen and the courge d'Italie varieties. In 1883, the year the seed was saved, we had no plants of these varieties upon the station grounds. There were also some unknown forms, but none that could be called strictly intermediate between the varieties, and some which represented each parentage.

Lettuce.—In 1883 the green fringed and the deer tongue lettuce was crossed. In 1884 the crop yielded forms which could be referred to the Batavian, Silesian and Malta drumhead varieties, and there were no intermediates between the parents. In this case we had the parents of two very distinct types, there being scarcely a point of resemblance in general appearance.

Pea.—In 1883 we had crosses between the sugar pea and the common pea. The 1884 crop from the crossed seed had the seed all of the sugar pea type, the pods all of the common type. The wrinkled pea crossed with the smooth pea gave wrinkled and smooth peas in the same pod, but no merging of the two forms.

This year is hence the second generation from the cross. The number of plants under observation have been numerous, occupying three-twentieths of an acre. The types of the plants are French upright and the common, without intermediate forms. The types of the fruit are French upright, Livingston's favorite, common red and great Chihuahua, and no intermediates that can be recognized. The last-named is precisely on type both in plant and fruit, but few plants as compared with the others.

French upright crossed by acme. First generation. The types of plant either French upright or acme. The fruit acme, French upright and common red, and no intermediates.

French upright crossed by alpha. Second generation. The type of plant both kinds. The French upright type of plants have all French upright type of fruit. The common type of plants bear fruit of the fig, pear, plum, alpha, common red, French upright and great Chihuahua type, and no intermediates that can be recognized.

Currant crossed by Livingston's favorite. First generation. The types of plant, mostly the currant, but some few plants of the common form, but slightly more upright. The fruit is racemed like the currant, but of far larger size, about 1¼ inch in diameter. Although I have never seen fruit of this character before, yet the plant and the fruit correspond very closely with the description of the Solanum racemosum, Cerasorum forma of Bauhin's Prodromus, ed. of 1671, p. 90; and we may legitimately suspect atavism has reproduced this apparently lost variety.

Turk cap crossed by several large varieties in 1882, such as acme, trophy, mayflower and paragon. The first generation was grown in the greenhouse, and hence the crop of 1885 is the fourth generation, the selections having been made each year for soundness and smoothness of fruit. The foliage of the 1885 plants somewhat variable but of the common type. The fruit can be referred to the apple, acme and common red. One plat from the earliest seed of this class has given constant foliage, and the fruit small, of the plum variety type, and of constant form.

These facts of careful observation and record are only explainable by the hypothesis that in certain kinds of cross-fertilizations and hybridizations the tendency of the crossed seed is to reproduce ancestral forms rather than intermediate forms. That there can be a blending of characters in certain cases is well known or certainly well asserted; but in the experience gained at the New York Agricultural Experiment Station, "sports" or blendings are rare in exact accordance with our familiarity with varieties. Thus in the case of the maize, at first we had many cases noted in our collection as variables; with the increase of varieties grown, and with increased specimens in our museum collection, these variables, almost without exception, could be referred to types or varieties, and the few exceptions to this statement occur in the little-studied class of pod or husk corns. Two illustrations will suffice: in New Jersey an excellent farmer there noticed a few pod ears in his crop of Blount's prolific dent and forwarded samples to the station as novelties. The seed from these pod ears reproduced with us Blount's prolific of perfect type and pod corn of the same type of ear which furnished the seed, and no variables from the two types noted. From the crossing of pod corn with sweet corn a new variety of sweet corn was produced, of a distinct type and esteemed by us a novelty in every respect, the cob being fusiform, the kernels horse tooth and much wrinkled, the stalk very small. At a later date this type appeared in our collections as the banana sugar, and was proven not to be original with us.

Darwin, in his Animals and Plants under Domestication, the New York edition of 1868, vol. II, p. 54, has a section entitled, "Crossing as a direct cause of Reversion," and says: "But that the act of crossing in itself gives an impulse toward reversion, as shown by the reäppearance of long-lost characters, has never, I believe, been hitherto proved." His line of evidence, however, is different from that here presented, and embraces a different series of observations.

The lack of agricultural museums in which domesticated varieties of plants find representation, the general ignorance of the varieties which were grown by our predecessors, and the in general careless descriptions which occur in the writings on agriculture, render a study of this sort embarrassing and difficult. A careful study, however, of the figures given by the botanists of the sixteenth century and thereafter, and a careful collation of evidence

gleaned from more recent authors on gardening, together with the fact that the appearance of new form-species of cultivated vegetables seems to date from the introduction of forms of the same species from distant regions, and the rarity of appearance of novelties which cannot be identified with some previously described type,[2] all encourage to the belief in the correctness of the generalization that in our domesticated vegetable plants cross-fertilization shows its effect at once in the reproduction of the form-species and varieties which are involved in the parentage of the crossed seed, and that when "pure seed" is crossed, intermediate forms rarely occur, but the original parents in variable proportions.

GERMINATION STUDIES. BY DR. E. LEWIS STURTEVANT, Director Agricultural Experiment Station, Geneva, N. Y.

IN 1879, I collected the seed from about 1200 Christiana melons, carefully selected for uniformity and quality. This seed was washed and carefully winnowed, dried, and then stored in bulk. In Sept., 1883, when four years of age, twenty-three duplicate germinations were made, fifty seed in a pocket, the conditions as nearly absolutely identical as could be secured, as the seed occupied the same apparatus, and was exposed to the same moisture and the same temperature. The first germination in all cases occurred on the second day, half of the seed in twenty-two of the twenty-three trials had germinated on the third day, and the last seed had germinated in from four to eight days. The average germination was 78 per cent, the extremes of the various samples 66 and 86 per cent.

A trial, in June, 1883, of Danvers yellow onion seed, said to have been grown in 1882, was in a series of fifty-one duplicates, fifty seed in a trial. The average germination was 89 per cent, the extremes of the samples 74 and 98 per cent.

The variation in these trials, calculated on the number of seeds used, was :—

[2] For instance, the deer tongue lettuce, with lanceolate leaves, which appeared about 1883, is almost identical with the Lactuca folio oblongo acuto figured in Bauhin's Prodromus, edition of 1761, p. 60.

No. of seed used.	Variation between samples. Christiana melon.	Per cent. Danvers yellow onion.
50	20	24
100	20	15
200	6	6
300	5	4
400	2	3
500	6	2

We have hence, an excellent illustration of the importance of number of seeds, if we would correctly interpret the comparative value of percentage figures gained in germination trials, and as a corollary suggestion, the uselessness of ordinary comparative trials between samples of a few seed each, as the variation between duplicates may be greater than would be found between different samples.

A further illustration of the difference which may occur between duplicates is offered in the following table, in which "exact duplicates" mean seed in adjoining recesses of the same apparatus, exposed to the same moisture and the same temperature; "duplicates" mean that the germination trials were made at different dates, but the conditions at the time as "near enough" duplicate. The seed, onion-seed of various kinds and ages, 100 seed used in each trial, from seedsmen's packages.

	Year of growth.	Per cent germinated. Dec. 6, '84. Exact dup.	Dec. 6, '84. Dup.	Dec. 20, '84. Exact dup.	Dec. 20, '84. Dup.	Duplicates. Average for Dec. 6, trial.	Average for Dec. 20, trial.
White Portugal	1882	30	33	35	52	31	43
White Globe	"	14	19	7	15	16	11
" "	"	39	39	50	51	39	50
Large Red Globe	"	13	16	15	15	14	15
" " "	"	34	40	41	42	37	41
" " "	"	28	32	33	34	30	33
Large Red	1883	38	40	87	90	39	88
" "	"	0	8	35	40	4	37
" "	1882	8	11	43	45	9	44
" "	"	9	12	51	57	10	54
Yellow Danvers	1883	42	42	61	64	42	62
" "	1882	21	23	49	53	22	51
Yellow Globe Danvers	1883	18	19	62	69	18	65
" " "	1882	25	33	67	68	29	67
Giant Rocco	1881	1	1	7	16	1	11
Globe Madeira	1883	8	9	44	58	8	51
" "	1881	3	6	32	33	4	32
Golden Queen	1883	27	31	60	65	29	62
Flat Madeira	"	17	17	45	51	17	48
" "	1881	6	7	17	22	6	19
Brown Teneriffe	1883	0	8	1	4	4	2
" "	1882	3	9	33	35	6	34
White Silver Skin	1880	0	1	0	0	1	0

The average of the twenty-three trials is 16.7 and 19.8 per cent on Dec. 6, or a variation of 3 per cent; 38.0 and 42.6 per cent on Dec. 20, or a variation of 4 per cent; and these under exact conditions. Between the two trials, the duplication being less exact, the seeds from the same pockets germinated in the trial of Dec. 6, an average of 18 per cent; in the trial of Dec. 20, the average germination was 40 per cent. We have here a difference of 22 per cent to be ascribed to the influence of conditions too slight for ready recognition, but probably a varying temperature which averaged very nearly alike in the two trials.

Our next illustration embraces three distinct trials, in which the temperature was designed to be uniform, but as a matter of fact the extremes were as noted, as also the number of hours. The experiments were continued until the 100 seed had either all germinated or rotted, the temperatures giving the maxima and minima during the trial.

	PER CENT GERMINATED.			TEMP. OF OFFICE.	
	400 hours. 41.5°-43.7°	396 hours. 40.8°-44.6°	427 hours. 41°-45.3.	Exact	dup.
CABBAGE.					
Henderson's Sel. Jersey Wakefield	100	98	99	95	97
Henderson's Early Summer	96	100	100	97	99
KOHL-RABI.					
White Vienna	72	66	71	86	89
KALE.					
Siberian	82	98	98	97	97
LETTUCE.					
Salamander	87	91	89	34	40
ONION.					
Red Wethersfield	95	84	88	95	97
Red Italian Tripoli	89	67	86	98	98
RUTA BAGA.					
Imp. Am. Purple Top	98	100	99	93	93
TURNIP.					
Purple Top Strap-leaf	81	97	92	92	95
Purple Top White	37	88	85	87	92

We might furnish many other tables of similar import, which confirm the general indication of the difficulty of deciding upon the meaning of variation in comparative tests of the germinating properties of commercial seeds.

As allied to the study of duplicates, we present some tabular data obtained in an endeavor to ascertain the lowest temperature at which maize can germinate. In these trials the seed was recorded as germinated when the acrospire had distinctly broken through the pellicle of the grain.

Our last trial was incomplete on account of the disarrangement of our apparatus at the 450th hour. From 11 A. M. March 16, 1885, to 4 P. M. April 4, the temperatures maintained varied from 37° to 42° F. The examinations of the thermometer enclosed with the seed as a check upon the thermostat numbered 210 readings. Of these four were 37°; one 37.5°; twelve were 38°; twenty-eight were 38.5°; one hundred and eight were 39°; twenty were 39.5°; thirty-two were 40°; one was 40.5°; two were 41°; two were 42°, these two at 9 and 10 A. M. April 3, when the apparatus halted until the rise was discovered, the 8 and 11 A. M. readings being 40°.

The Chester County Mammoth Dent showed first germination in 430 hours; the Waushakum Flint in 460 hours, the Amber Rice Pop so near germination at the 450th hour as to be doubtfully rejected. The apparatus after the 4 P. M. count, April 4, was left exposed to the temperature of the office, say 72° to 78° F., and at 4 P. M. April 5, or twenty-four hours later, one hundred per cent of germinations were noted for all.

The following table represents the hour in which the first seed was noted as germinated, at various temperatures:—the seed in all the trials was taken from the same ear.

FIRST GERMINATION, IN HOURS, AT VARIOUS TEMPERATURES.

	37°-42°	41°-43.7°	43.5°-47.8°	41°-49.6°	45.3°-50.7°	48.5°-55.5°
DENT FORM-SPECIES.						
Adams Early		233			180	142
Chester Co. Mammoth	430	233	264		168	142
Golden Beauty		401				
Queen of the Prairie		401				
Mammoth White Surprise		479				
Farmers' Favorite Golden		521				
FLINT FORM-SPECIES.						
Waushakum	460	331	336		228	142
Eight-rowed White		331			216	150
Golden Dew Drop		498				
King Philip		498				
POP FORM-SPECIES.						
Dwarf Golden		498			228	141
White Pearl		378	336		228	141
Amber Rice		378			228	141
SWEET FORM-SPECIES.						
Stowell's Evergreen		452		504	288	185
Narragansett		498			300	209
Black Sugar		479				
Squantum		498				
Hickox Improved		616				
Mammoth		616				
Large Early Eight Rowed		521				
SOFT FORM-SPECIES.						
Tuscarora		378		408	228	161
Zuni blue		431			228	185

We note some variations in this table which can only be accounted for under the assumption of individual variation, or the difficulty of obtaining duplicate seed. Thus the Chester Co. Mammoth gave its first germination in 264 hours at 43.5° to 47.8° temperature, and the 233rd hour at the cooler temperature of 41° to 43.7°. Stowell's Evergreen germinated the 504th hour at 41° to 49.6° temperature, and the 452nd hour at the 41° to 43.7° temperature. This seed individuality constantly appears in germination trials, as when tomato seeds germinate irregularly during a period extending oftentimes over twenty or more days under identical exposures.

During these trials at low temperatures, none of the seed rotted; and at the conclusion of the trial, usually brought about by the cessation of our water flow, whereby the temperature was kept cool, the seed exposed to the temperature of the office germinated usually one hundred per cent, and furnished strong and vigorous growth.

THE QUESTION OF BISEXUALITY IN THE POND-SCUMS (ZYGNEMACEÆ). By Prof. CHARLES E. BESSEY, University of Nebraska, Lincoln, Nebraska.

[ABSTRACT.]

THIS paper is devoted to a discussion of the question whether the conjugation observed in the Zygnemaceæ is bisexual in character. Certain structural facts indicate some differentiation of the filaments into male and female. On the contrary, other facts indicate that the filaments have not become sufficiently differentiated to be distinguished as of different sexes. After the citation and discussion of facts bearing upon the question the conclusion is reached that these plants possess an undifferentiated sexuality and that they may be designated as *unisexual*, in contradistinction to higher plants which are *bisexual*.

The conclusion is also reached that on this account the Zygnemaceæ are to be placed among the lower Thallophytes, but little above the asexual Protophytes.

FURTHER OBSERVATIONS ON THE ADVENTITIOUS INFLORESCENCE OF CUSCUTA GLOMERATA. By Prof. CHARLES E. BESSEY, University of Nebraska, Lincoln, Neb.

[ABSTRACT.]

LAST year I called the attention of the Association to the fact that this dodder produces its flowers upon short, adventitious branches, which themselves repeatedly branch and are closely covered with scales. A further examination shows that this is the universal rule with this species, no normal inflorescence developing. The adventitious inflorescence always bears a definite relation to the position of the parasitic roots: that portion of the stem which produces roots always produces adventitious inflorescence, and the greater the number of roots, the greater the inflorescence. No adventitious inflorescence is produced upon any portion of the stem which does not bear roots. The stem proper all dies away soon, not only *between* the inflorescences, but also in the flower clusters themselves. The flowering branches establish direct structural connection with the host plant. When the latter is accomplished, the scales upon the flowering branches often contain considerable quantities of chlorophyll.

PROTHALLIUM OF FERNS. By DOUGLAS H. CAMPBELL, Detroit, Mich.

[ABSTRACT.[1]]

THE following points were dwelt upon: first, the value of the study of development for a full appreciation of the true place of plants in a classification, and the advantages which ferns offer in the development of the prothallium for such study, on account of their wide distribution and the readiness with which the spores can be germinated.

Second, the methods employed in growing the prothallia, with results obtained by different ones, the conclusion being reached that those grown on earth developed in a more normal manner than under other circumstances.

Third, the development of the prothallium from the spore was

[1] Published in full with illustrations in the Botanical Gazette, Sept. and Oct., 1885.

traced up to the time of the formation of the sexual organs, statistics being given as to the time of the appearance of these and their number.

Fourth, the presence of a third coat in the spores of the genus *Onoclea*.

Fifth, The marked dicœciousness of the three ferns specially studied, *Onoclea struthiopteris*, *Onoclea sensibilis* and *Asplenium filix fœmina*, and the simple character of some of the male prothallia.

THE PROCESS OF FERTILIZATION IN CAMPANULA AMERICANA L. By Prof. CHARLES R. BARNES, Lafayette, Ind.

[ABSTRACT.]

THE species is strongly proterandrous. The pollen is scraped out of the anthers by the hairy style and brushed off that before the stigmas open, thus securing cross-fertilization.

The development of the pollen is normal.

The stigmas are held together till mature by interlocking papillæ.

The hairs on the style become partially introverted, thus freeing the pollen.

The pollen-spore contains two nuclei, the larger of which, the vegetative, becomes disorganized shortly after entering the pollen-tube; the smaller, spindle-shaped, generative nucleus persists.

The embryo-sac is cylindrical, with a gradual enlargement near the micropylar end where is located the egg-apparatus, and an abrupt enlargement at the chalazal end, in which lie the antipodal cells. There are usually two sac nuclei.

The pollen tubes enter the style *between* the bases of the papillæ of the stigma, pass down in the strands of conducting tissue and *not* through the central canal, around which this tissue is arranged.

The paper was followed by an account of the methods used.

On the appearance of the relation of ovary and perianth in the development of Dicotyledons. By Prof. John M. Coulter, Wabash College, Crawfordsville, Ind.

[ABSTRACT.[1]]

Two years ago, in an organogenic study of the dandelion flower, my attention was called to the fact that the character of inferior ovary was the first to make its appearance. Since then this hint has been somewhat extensively followed up, and the results form the reason for the present paper.

Among Angiosperms, the present grouping of Dycotyledons is most unsatisfactory, as long recognized by botanists. A group called *Apetalæ*, intercalating most intricately with *Polypetalæ*, is yet separated from them by *Gamopetalæ*, which are more highly developed than either.

As embryology has been of such invaluable aid in zoölogical classification, it is but reasonable to suppose that organogeny may be able to play some such part in botany.

Upon the discovery that the inferior ovary was the first character to appear in the development of the dandelion flower, a somewhat extensive examination of the larger dicotyledonous families was begun, to discover how the character was sustained. Many species were examined from the families Ranunculaceæ, Leguminosæ, Rosaceæ, Saxifragaceæ, Onagraceæ, Rubiaceæ, Umbelliferæ, Compositæ, Borraginaceæ, Scrophulariaceæ and Labiatæ. The result was, that in every case the first character recognized in the development of the flower, was that of inferior or superior ovary, and a most simple grouping upon that basis was apparent. In the case of an inferior ovary, the protuberance which is to develop into the flower, is arrested in its axial development, grows peripherally into a collar (the nascent floral envelopes), and soon there appears an external constriction, distinguishing the floral envelopes above from the ovary below. In the case of a superior ovary, the axial development is continued, and there is no external constriction. All this is perfectly clear before any character is furnished by the floral envelopes.

Grouping Dicotyledons upon this basis results somewhat as follows: *Compositæ* at the head of the list, already for some time considered of highest rank, and near them such groups as *Umbell-*

[1] This paper is published in the Botanical Gazette for Sept. and Oct., 1885.

iferæ, *Rubiaceæ*, etc. Of course, in all natural classifications there is a series of intermediate forms whose relationships are hard to determine. Intermediate between inferior and superior ovaries stand such groups as *Rosaceæ* and *Saxifragaceæ*. The second group, that of superior ovaries, includes *Leguminosæ*, *Scrophulariaceæ*, *Labiatæ*, etc., and so on through the polymorphous *Ranunculaceæ* to other Polypetalæ and Apetalæ. Such a grouping, expressed in the terms of our present classification, would arrange Dicotyledons as follows:

I. Gamopetalæ, with inferior ovary, and some Polypetalæ (Compositæ, etc.).

II. Gamopetalæ, with superior ovary, and some Polypetalæ (Leguminosæ, Labiatæ, etc.).

III. Remaining Polypetalæ and Apetalæ intercalated.

The above must be recognized not as a presented classification, but simply as tracing some of the possible results of organogenic study.

PROOF THAT BACTERIA ARE THE DIRECT CAUSE OF THE DISEASE IN TREES KNOWN AS PEAR BLIGHT. By Prof. J. C. ARTHUR, Geneva, N. Y.

IT has now been five years since Prof. Burrill brought the subject of pear blight before this Association and announced that it was due to bacteria. Previous to that time no instance of bacteria acting the rôle of vegetable parasites had been known, and the discovery was therefore a very important one, opening the way to a new and promising field of research.

The experiments of Professor Burrill showed that the disease alluded to was invariably accompanied by a specific form of bacteria (since named *Micrococcus amylovorus* Burrill), and that as the disease progressed a colorless or yellowish viscid substance was formed, apparently by the action of the bacteria upon the starch and other substances of the plant. The disease results in the complete death of all those parts of the tree that are attacked.

Although from these and subsequent investigations, the theory has been quite generally accepted that the bacteria are the cause of the disease, no rigid proof of it has yet been brought forward. It

was with a view to either absolutely prove or disprove the theory that a course of experiments was begun last March and continued to the present time.

It had been incontestably shown that the disease may be readily transmitted to healthy tissues by introducing a drop of an infusion made by putting some thin slices of the diseased tissues in water,[1] or by simply transferring a minute portion of the exudation from the diseased to the healthy shoot.[2] The problem was consequently narrowed down to one of two alternatives, either the bacteria were the cause of the disease or the juices which accompanied them were the cause of it.

The first attempt was to secure some inoculating material in which the bacteria were entirely freed from the juices of the disease. This was done by means of a succession of artificial cultures in a sterilized infusion of corn (maize) meal. Two series were successfully carried through, extending over about four months, and an inoculation from the sixth culture of each introduced into the green fruit of a Bartlett pear.

No. of culture.	*Date of infection.*	*Kind of culture vessel.*	*Amount of fluid.*
301	Mar. 27,	Salmon culture tube,	20 cc.
302	Apr. 1,	" " "	20 "
307	" 21,	Sternberg culture flask,	½ "
309	" 24,	" " "	½ "
314	May 22,	" " "	½ "
322	June 5,	Test-tube with Fol stopper,	25 "
364	July 13,	Bartlett pear on tree.	

The accompanying tables will show the kind of culture vessels used, the amount of culture fluid they contained, and the date at which each one was started. The first culture of the series was infected with a very small fragment of wood taken from the inner portion of a diseased limb of Flemish Beauty pear, in which the disease had been slowly advancing during the winter, from an inoculation made July 26, 1884, with an infusion of blighted twig from an apple tree. The infection of each of the other cultures of the series was successively made with a small drop of the one

[1] Arthur, Bull. N. Y. Agric. Exper. Station, XCII: 3rd Ann. Rep. N. Y. Ag. Exper. Station, p. 358.

[2] Burrill, Amer. Assoc. Adv. Sci., XXIX, p. 589; Amer. Naturalist, XV, p. 529. Arthur, l. c.

preceding. From the last culture a drop was transferred to a puncture in an unripe Bartlett pear. In both cases the pears were soon filled with the disease. They did not turn brown about the wound as is the more usual way, but first indicated the presence of the disease by beginning to shrivel, which occurred in one case, in nine days after inoculation, and in the other in ten days. Upon cutting the pears open the softer tissues were found broken down and liquefied, and a milky viscid juice ran out, showing that the disease had taken thorough possession.

No. of culture.	*Date of infection.*	*Kind of culture vessel.*	*Amount of fluid.*
301	Mar. 27,	Salmon culture tube,	20 cc.
302	Apr. 1,	" " "	20 "
307	" 21,	Sternberg culture flask,	½ "
309	" 24,	" " "	½ "
310	" 27,	" " "	½ "
320	June 5,	Test-tube with Fol stopper,	25 "
362	July 13,	Bartlett pear on tree.	

By this means of fractional culture the juices accompanying the bacteria first introduced were so much diluted in the transfers to succeeding cultures that the final drop used to inoculate the pear was practically free of them, and to the bacteria only, supplied by continued growth and multiplication, can we ascribe the last result.

Having shown that the bacteria when isolated from their juices are able to cause the disease, it still remained to show what action the juices would have when separated from the bacteria. On July 18, a strong infusion of blighted pear was filtered through a porous earthenware vessel, such as used for small electric batteries, and an unripe Bartlett pear inoculated with the filtrate and another pear with the infusion used for filtering. In a week the latter was thoroughly blighted, while the former showed no signs of injury except the slight wound, which finally healed. On July 24, another strong infusion of pear blight was filtered through a second battery cell. Both of these cells were new, and had never before been used for any purpose. In this case two unripe Bartlett pears were inoculated with the unfiltered infusion and two others on the same tree with the resulting filtrate. Both the former showed strong evidences of the disease within three days, while the

latter soon healed up the small wounds made by the inoculation, and have continued their normal growth.

The evidence is thoroughly satisfactory and conclusive — the bacteria accompanying the disease of trees known as pear blight when fully isolated will produce the disease, while the juices in which they live will not. They are, therefore, the direct cause of the disease.[3]

THE MECHANICAL INJURIES TO TREES BY COLD. By Prof. T. J. BURRILL, University of Illinois, Champaign, Ill.

[ABSTRACT.]

THE injuries to the trunks of trees resulting from too low temperature may be of several distinct kinds, with or without apparent disturbance of the structure. But in this paper mention is made of those in which the tissues are mechanically ruptured and visible wounds are produced. Of these latter there are two distinct forms of injury.

In one case the bark and wood split in a longitudinal, radial direction so as to gape open while frozen and nearly close again upon the return of warm weather.

The second form of injury—followed by much more serious results—is the separation of the bark from the wood or of concentric layers of wood corresponding with the annual layers of growth. The most detrimental consequences result from the rupture of the cambium layer, severing the bark from the wood, killing the tree when the wound extends entirely around its trunk.

In attempting an explanation of these occurrences, the common phenomena attending the crystallization of water in its pure state and as combined with other substances are recited in the paper, and the structure of vegetable tissues, as far as necessary for the purpose, is explained.

It is then shown that the longitudinal radial cracks are principally due to the shrinking of the tissues with the decrease of heat, just as they occur upon dessication. But such cracks may be partially due to the expansive force of freezing water after the fashion

[3] This paper is also published in the Botanical Gazette, vol. X, p. 343, and Gardeners' Chronicle, vol. XXIV, p. 586.

of the bursting of a water pipe. Such cracks, however, do not occur until the temperature sinks many degrees below the freezing point for pure water, but not necessarily below that of the water as it exists in its state of molecular distribution among the structural elements of the plant. Upon observation it has been found that in the perennial tissues of hardy trees in healthy winter condition ice rarely forms at 10° Fahr.; not very frequently at zero, more often at — 6° to —12°; quite commonly at —15° to —20°, but sometimes not even at — 28° Fahr. Yet from this same wood, heart as well as sap wood, 40 per cent of water may be evaporated at a temperature a little below that of boiling water. The water is present, but owing to the molecular adhesions between the water and the elements of plant tissues the movements necessary for crystallization do not take place until the temperature designated is reached. We need not appeal to what is known as "vital resistance" to account for the phenomenon.

The second form of injury—especially prevalent in apple trees —is believed to be due to the *growth* of ice crystals studding in a close or dense layer the surface upon which they form. Such miniature forests of crystals can be found in green plants even after slight freezing, as well as in ripened wood in severely low temperatures.

In the trunks of trees the crystallizations begin in any part where there is proportionally most pure water. The very process of solidification causes, by the law of equal diffusion, a movement of water from adjoining parts towards the point from which the first liquid (as such) is removed. Hence the ice crystals first formed constantly grow, attracting as it were the water from neighboring parts of the tissue. This growth of the crystals, associated as they occur in close layers, pushes asunder the normally connected tissues. If the cambium layer is the seat of the ice formation the whole bark is thus separated from the wood. If the more porous portions of the annual rings of the wood itself are thus filled with ice the structure may be ruptured in concentric layers of greater or less thickness. This seems to occur most often in old trees, and what are called "windshakes" are in reality mostly due to frost.

Such being the case, it is easy to see that the condition of the tissues with respect to the content and molecular association of water has much to do with the degree of cold plants may with-

stand without injury. What we call ripeness in wood and bark largely relates to the amount and condition of the contained water; hence materially affects the ability of trees to pass without injury the vicissitudes of winter. Ripe seeds contain about ten per cent of water. This latter does not freeze during our coldest weather. The wood of living trees contains forty per cent of water and this does freeze as we have seen at temperatures below Fahrenheit's zero. Whenever this occurs to a sufficient extent, rupture of the tissues follows, not by the bursting of individual cells like earthen vessels containing water, but by the forcible pushing asunder of parts as the numerous though isolated crystals increase in length. Whatever tends to increase the amount of water, structurally free in living wood, tends to expose this to destruction by frost, and so far as mechanical ruptures are concerned the degree of temperature at which destruction begins varies inversely with the free water present.

NOTES ON SOME INJURIOUS FUNGI OF CALIFORNIA. By Prof. W. G. FARLOW, Harvard University, Cambridge, Mass.

DURING a recent trip to California I had an opportunity of observing some injurious fungi which attack the native plants and, as they may hereafter be the cause of disease in cultivated plants, it may be well to call the attention of the members of this society to a few facts with regard to them.

In travelling in Mexico, the attention of the botanist is attracted by the pleasing foliage and graceful habit of *Nicotiana glauca* Grah. which is abundant along the railroads and highways where it often attains a height of ten feet or more. This shrub or small tree is a native of Buenos Ayres, but is thoroughly acclimated in Mexico and is occasionally cultivated in the greenhouses of our northern states. Within a few years it has escaped from cultivation in California and is now a common roadside plant from San Diego to Los Angeles and Santa Barbara and also occurs, but less commonly, still farther to the north. While in San Diego, I noticed that the leaves of the Nicotiana were badly attacked by a fungus which formed large, grayish black spots on both sides of the leaves. The spots were often two inches in

diameter and sometimes even larger, and the circumference was irregular but sharply limited, so that the transition from the healthy to the diseased leaf-tissue was sudden.

A microscopical examination shows that the fungus in question is *Peronospora hyoscyami* De Bary which was first found on *Hyoscyamus niger* L., in Europe, where it does not appear to be at all common. Both in Europe and California, the spots formed on the leaves are large and the surface is densely covered with a luxuriant growth of conidia, but, so far as I know, no oospores have yet been found in this species.

Since it is well known that the species of Peronospora attack different species of flowering plants which belong, botanically speaking, to the same natural order, it is much to be feared that the disease which now attacks *Nicotiana glauca* may sooner or later extend to the cultivated tobacco which belongs to the same genus. If this happens, the injury to the tobacco would be very great, since, by causing large spots on the leaves to rot, they would become worthless for manufacturing purposes. We must, at least, consider the probabilities with regard to the spreading of the disease.

The fungus was only observed by me at San Diego, but it was abundant there. Whether it occurs in Mexico or not, I cannot say; but my opportunity for observing in that country was so limited that the fungus might have been very abundant there and still escaped my notice. At Santa Barbara, however, I was able to make a pretty careful search, and, as far as I could ascertain, the disease has not yet made its appearance there; but, from what we know of the history of the spreading of diseases caused by other species of Peronospora, there is every reason to suppose that the disease which we are now considering will soon reach Santa Barbara. As tobacco is not an important crop in California, we are less interested in the spreading of the disease in that state than in its extension to the southeastern states. The *Nicotiana glauca* may perhaps spread northward and eastward until it reaches the gulf states carrying with it the Peronospora; but it is too tender to stand the winters farther north without protection. What is also to be feared is that in advancing eastward the fungus may be communicated to some species related to *Nicotiana glauca*, as, for instance, *Hyoscyamus niger*, and thus be transported north of the limit where the *Nicotiana glauca* might grow, but where *N.*

tobacum, the tobacco plant, is cultivated. But this supposition is almost superfluous, because if *Nicotiana glauca* and its parasite are once introduced into the gulf states, the parasite might attack the tobacco grown there and then pass on to Virginia and other states where tobacco is the most important crop.

At the Minneapolis meeting I stated in a paper read before the society that *Peronospora Halstedii*, although one of the commonest species on Compositæ in the eastern and central states, had not yet been found either in the extreme south or on the Pacific coast. I am indebted to Dr. H. W. Harkness for specimens of a Peronospora growing on *Madia sativa* near San Francisco, which is identical with *P. Halstedii*, so that this typically American species extends quite across the continent. *Peronospora leptosperma* De Bary, known in Europe and in the Mississippi valley, I also found to be common at Santa Barbara and Santa Cruz on *Artemisia Ludoviciana*.

The hollyhock disease, *Puccinia malvacearum* Mont., which was originally noticed in Chili, has, in recent years, spread over Europe and its progress has been more carefully watched by botanists than that of any other plant disease, the potato rot and grape mildew perhaps excepted. But while the two diseases last named extended to Europe by way of North America, the hollyhock disease apparently was conveyed directly from South America to Europe and did not pass through the United States.

The only reference to the existence of the hollyhock fungus in this country is in the Catalogue of Pacific Coast Fungi by Harkness and Moore, where it is said to have been found on Malva near San Francisco. A fungus related to the hollyhock fungus has been observed on species of Malvastrum in the western states and California. It was first seen by Mr. D. Cleveland near San Diego in 1875 and has been seen several times since. By some the fungus on Malvastrum has been considered distinct and even those who have considered it a variety of *P. Malvacearum* have regarded it as distinctly unlike the form found on hollyhocks. When in California I examined with care the different Malvaceæ to which order the hollyhock belongs, to see whether the true hollyhock fungus did not occur in that state. During a visit to the garden of Mrs. Elwood Cooper near Santa Barbara, I found the hollyhocks covered with a Puccinia and in a cañon near the garden I also found a few leaves of *Malva borealis* L., on which

was the same fungus. I at first supposed that what I had found was the hollyhock disease of Europe and South America; but closer examination and a careful comparison with European specimens showed that the form found at Santa Barbara was not the European form, but, on the contrary, precisely the form already known on Malvastrum in this country. This is to me rather surprising, for, if the fungus on Malvastrum is only a variety of the hollyhock fungus, when the disease appears on hollyhocks in this country it should appear in its typical form; and, on the other hand, if the Malvastrum fungus is really a distinct species then the hollyhock disease of Europe is not the hollyhock disease of this country, although both are caused by nearly related Pucciniæ of the subgenus *Leptopuccinia*. A detailed account of the differences recognized in the two forms mentioned is only of interest to mycologists and a discussion of the subject will come up more appropriately in another connection. In case of the fungus in question one should consider the possibility that it may attack the cotton plant at some future date, although Cesati states that *Puccinia malvacearum* has not attacked the cotton in Italy. As far as our own cotton is concerned, danger is rather to be apprehended from *Puccinia heterospora* B. & C., which in its different forms is widely distributed on different Malvaceæ in the southern states.

A New chromogenous bacillus. By Dr. D. E. Salmon and Dr. Theobald Smith, Department of Agriculture, Washington, D. C.

This bacillus which we have provisionally named *Bacillus luteus suis* was obtained from three separate cases of swine-plague, one occurring in November, 1884, the others in April and May, 1885, respectively. In each case the bacillus was isolated from other germs by means of plate cultures according to Koch's method. In the first case the source of the bacillus was a liquid culture from pericardial effusion, in the two others it was the peritoneal effusion, that contained the bacillus. It is probable that the bacillus is normally an inhabitant of the intestine in the pig and that its presence elsewhere in the fluids of the body is due to lesions of the intestinal tract.

If a plate-culture of this microbe be prepared according to the accepted methods and exposed to a temperature of 70-80° F., it will be found covered with minute grayish points within twenty-four hours. The points, examined with a 1-inch objective, are found to be spherical, with boundary well defined by a dark line, and from .025 to .050 mm. in diameter. The mass of the colony has a pale, finely granular appearance with transmitted light. Within forty-eight hours the sphere loses its homogeneous appearance. Faint lines map it out into irregular portions, thus giving it a mulberry appearance. Somewhat later the centre becomes more opaque, and a faint, narrow border, striated radially, may be made out with ½ inch objective and high eyepieces. The appearance of the colony may differ somewhat from the above description, depending on the density of the gelatine layer. The gelatine medium, used throughout, varied but slightly from a ten per cent solution. The appearance will also depend upon the situation of the colony, whether within or on the surface of the gelatine layer. When on the surface, the colony spreads quickly and forms an irregular depression due to its power of liquefying the gelatine. The colonies beneath the surface remain spherical until they touch the surface, then liquefaction rapidly progresses and the colony assumes its most characteristic appearance. This occurs from two to four days after the preparation of the plate, the time depending on the temperature of the room and the thickness of the gelatine layer. The colony is now represented to the naked eye by a concave depression from 2 to 3 mm. in diameter, covered by irregular, yellowish masses. Under a 1-inch objective and with transmitted light these masses or clumps are seen to condense towards the centre into a kind of nucleus. Towards the periphery they grow smaller and more delicate until lost in finely granular patches. A dark border, due to refraction, bounds the colony. At this stage the transparent gelatine around the colonies becomes stained with a greenish yellow color which spreads *pari passu* with the growth of the colonies until the entire gelatine layer is converted into a yellowish, opaque liquid readily flowing from the plate when the latter is inclined.

If a minute portion of such a colony, at an age of from one to two days, be removed with a needle, and placed with a drop of sterile distilled water on a slide and thoroughly mixed with it, it will be found, when magnified 700 to 800 diameters, to be made up entirely of rod-shaped bodies or bacilli from 1.2 to 1.5 micro-millimetres

long and .4 to .5 micro-millimetres in diameter. They occur isolated or in pairs. In the former state they may reach a length of from 2.5 to 3 micro-millimetres before division. The place of division becomes quite wide in most pairs before final separation and appears slightly contracted. The isolated rod is not square at its extremity but gently rounded. The question of spore formation has not yet been settled. If it should be found that the microbe under consideration does not produce spores, it would probably be better to class it among the bacteria proper, since the remaining characters, as indicated above, belong partly to one genus, partly to the other.

At a certain stage of growth the bacillus is motile. When a drop, taken from a liquid culture, is examined under a high power, the bacilli will be seen moving in straight or curved lines very rapidly across the field. When the movements become somewhat slower, some may be observed with one end stationary and acting as a pivot about which the rod itself revolves very rapidly. Sometimes a pair may be seen moving across the field and at the same time revolving about the point of division, each describing the surface of a cone. In all these movements, no bending of the rods themselves was observed. When taken from a culture in gelatine, the same movements are observed.

Cultivation in fluid media. If a portion of a colony be transferred with a flamed needle from the gelatine plate described above, into a culture-tube containing about 10 cc. of a perfectly limpid, sterile meat infusion and the tube kept at about 100° F., the liquid will become uniformly clouded and of a pale straw color within twenty-four hours. The surface is covered with a delicate, whitish, wrinkled membrane, which pushes its border for a short distance up the sides of the tube. Violent shaking causes the membrane to mass together and subside; it is, however, replaced by another within twenty-four hours. The color of the turbid liquid becomes orange with a greenish tint in several days. After one or two weeks the suspended matters slowly subside, and the termination of growth is indicated by a limpid condition of the liquid which has meanwhile deepened in color and in a month or six weeks, becomes amber. The deposit in the bottom of the tube, observable after the first day, increases to the end of growth.

These liquid cultures afford the best means for the more detailed examination of the pigment. They show that the bacillus is chro-

mogenous, and that the pigment produced is soluble in the culture liquid. They also point out that it is aerobic, since it grows during a portion of its vegetative state on the surface of the liquid. The liquid media employed were slightly alkaline infusions of meat. The reaction at the end of several weeks was strongly alkaline. Several cultures made in a 3 per cent solution of Liebig's meat extract, sp. gr. 1.0116, not neutralized and therefore markedly acid, were found strongly alkaline after a month. This would indicate that the bacillus is capable of flourishing in moderately acid media and produces an alkaline condition of those media. In connection with these facts, it was also noticed that the solution of meat extract was quite viscid throughout and that the deposit in the bottom had the ropiness of white of egg. Whether this condition was due simply to the enormous multiplication of the bacilli, to the degeneration of their substance, or to the formation of gelatinous envelopes, cannot be said. The second supposition seems the most plausible.

Cultivation in milk. The multiplication of this bacillus in milk presents many peculiar phenomena. The milk, sterilized by discontinuous boiling and inoculated from a pure culture, shows after thirty-six to forty-eight hours, a narrow zone of clear liquid gradually growing deeper, beneath the surface layer of cream. The casein is evidently precipitated and subsiding. Within four or five days a quantity of milk, about 5 cm. deep, will present the following layers: on the surface, a whitish, flaky layer intermixed with oil-globules, about $\frac{1}{2}$ cm. deep; beneath this a clear watery liquid tinged yellow, about $2\frac{1}{2}$ cm. deep; below this, a semi-translucent, gelatinous material about $\frac{1}{2}$ cm. thick; and, finally, in the bottom of the tube, a white, flaky deposit $1\frac{1}{2}$ cm. thick, representing the remaining casein. The later changes consist chiefly in an increase of the liquid at the expense of the solid matter. The liquid, at first colorless, becomes light yellow, finally yellowish-red. The reaction becomes markedly alkaline in a few days. It seems probable that the changes above described may be interpreted by assuming that the casein is at first precipitated, then slowly peptonized and dissolved, the gelatinous layer being an intermediate form of the casein before final solution.

It was in connection with the peculiarities of the milk culture that our attention was called to Schröter's investigations of pigments formed by bacteria. (Beiträge zur Biologie der Pflanzen," I,

1, 2, p. 120.) He found milk turning yellow spontaneously and undergoing changes very similar to those just described. The behavior of the pigment towards chemical reagents differed very little from that of the bacillus under consideration. Yet the description of the bacillus is so meagre, and pure cultures were not obtained, that we prefer to keep the two species apart until the bacterium of yellow milk, *Bacterium synxanthum*, shall be described and studied according to present accepted methods and from cases of yellow milk arising spontaneously.

Tube cultures in *nutritive gelatine* are quite characteristic and deserve a careful description. Yet the want of accompanying illustrations makes this a task of doubtful utility. We shall simply point out the most salient features. If a needle charged with bacilli be pushed into nutritive gelatine contained in a culture tube, the track of the needle, at the end of twenty-hours, will be indicated below, by a number of opaque points, the centres of growth of the individual bacilli; above, by a slender inverted cone, its base coinciding with the surface of the gelatine. The cone represents the space liquefied by the bacilli. It grows both laterally and downwards and gradually invades the isolated colonies in the lower portion of the needle track until the major part of the gelatine has been reduced to a fluid condition. At this stage, a whitish membrane forms on the surface, the fluid condition of the gelatine permitting the motile bacilli to rise. The liquid gelatine assumes a lemon yellow tint, which gradually deepens until growth ceases. Space forbids us to enter into any of the minor features which characterize the culture of this bacillus.

Serum culture. Coagulated blood serum is likewise slowly liquefied from above downwards; the liquid portion assumes a deep olive green color and is topped by a brittle, whitish membrane. Cultivated on *agar-agar*, the bacilli do not multiply beneath the surface but spread out upon it in a thin grayish layer with a translucent margin. Within a few days the *agar-agar* around the growth becomes deeply tinted. After several weeks the entire mass of *agar-agar* is tinted lemon yellow. The tint is even communicated to the water of condensation present.

We shall be forced to pass over the description in detail of the cultivation of this bacillus on potato, and simply mention the fact that the color of the patch, at first brick-red, changes within a week into a dark green, while the mass itself becomes very gelatinous.

Coloring matter. The cultures in the various media, just described, besides offering many diagnostic points, reveal not only an active chromogenous function but also certain peptonizing powers. Its action on boiled fibrin, casein and egg-albumen have not been attempted for want of time. A few facts concerning the pigment itself have, however, been ascertained. It is most readily obtained from cultures in milk or meat infusion by evaporating to dryness over a waterbath, removing the fat of the milk with ether, redissolving in distilled water and filtering. A perfectly clear filtrate is thus obtained containing the pigment in solution which may then be examined chemically and spectroscopically. The color of the solution varies, according to the amount of concentration, from an orange or yellow to a deep amber.

The pigment is insoluble in absolute alcohol and ether, neither of which takes up any after all water has been driven off by evaporation. The aqueous solution is nearly, but not entirely, decolorized by the addition of a large quantity of concentrated nitric or hydrochloric acid. The original strength of color returns however, if the acid be neutralized with an alkali, such as potassium hydrate or ammonia. Schröter's (l.c.) results thus far coincide very closely with our own; but he states that the color produced by the bacterium of yellow milk disappears when a very small quantity of a mineral acid is added. In the above experiments a large quantity of acid was necessary. He also speaks of its resemblance to an aniline yellow. Of several related aniline colors, we found that napthol yellow was soluble in water but insoluble in absolute alcohol. Its depth of color was also considerably reduced by acids and restored by alkalies. It cuts off the blue end of the spectrum very sharply as far as 51 of the scale, but has no absorption bands. The spectrum of the bacillar pigment likewise presents no absorption bands. In layers 1.5 to 2 cm. deep, all the blue end of the spectrum as far as 51 of the scale (including a portion of the green) is intercepted. These resemblances do not warrant any conclusions as to the identity of the two pigments. In all the cultures which have been examined, both in fluid and in solid media, a peculiar, characteristic odor always manifested itself, somewhat like that emitted from molten glue. No putrefactive or offensive odor was ever encountered in any pure culture.

A number of cultures were made to determine, if possible, the behavior of the bacillus in impure cultivations. In every case the

bacillus actively multiplied, as indicated by the pronounced coloration of the fluid within a few days, whether the various bacteria were sown together in approximately the same quantity or whether the bacilli were reduced to $\frac{1}{500}$ the number of the other bacteria. Even when the fluid had been rendered turbid by other bacteria for 16 hours, the addition of a drop from a pure culture of the bacillus produced the characteristic color. It would seem, therefore, that the presence in a mixed liquid culture of this bacillus is readily recognizable. The advantages arising from the use of a bacillus with such properties in many experiments need not be insisted upon, and we hope that the study of this microbe, when completed, may serve other useful purposes in the comparatively untrodden field of bacteriology.

This bacillus appears to have no pathogenic effects.

THE IMPORTANCE OF INDIVIDUAL FACTS OF ENVIRONMENT IN THE FORMATION OF GROUPS OF ANIMALS. By Prof. J. B. STEERE, University of Michigan, Ann Arbor, Mich.

THE close connection between living animals and their surroundings is generally recognized and admitted, as well by those believing in creation by design as by those holding to evolution.

This relationship is usually restricted to species and supposed to consist in a fitness of the specific structure to the general surroundings.

The natural divisions of the primary types or branches of animals are related to individual facts of environment now existing or having existed, and this is as true of the more fundamental and comprehensive as of the smaller.

No connection of the types or branches of animals with special facts of environment is observable.

The facts of environment are too numerous and too incompatible, for any one form of life to become related to all of them.

If all organisms were related to all the facts of environment and in the same degree, then all organisms would be alike.

Organisms differ as they become related to different facts of environment, and because they are so related.

The facts of environment differ among themselves in their rela-

tive value and also in their special importance to any given organism.

The facts of environment differ in kind as well as in value.

The facts of environment differing indefinitely in kind and value, the groups of animals founded upon them vary indefinitely and allow of no symmetrical classification; classes, orders, etc., have no existence in nature.

In general those facts of environment which are known to have existed before the creation of life and ever since, have produced the deepest and most lasting modifications and divisions such as classes and orders. Those facts which are and have been in a state of change are related to those divisions which are in the most rapid process of creation and destruction, as varieties and species.

The classes of vertebrates are related to the distinct horizons capable of being occupied by the type.

There are five of these: 1st, water, occupied by fishes; 2nd, the shallow border between land and water, occupied by amphibia; 3d, the surface of the earth, occupied by reptiles; 4th, the trees and the horizon immediately above the reptiles, by mammals, and 5th, the air, occupied by birds.

Articulates are related to nearly the same set of facts.

The molluscan type being from its nature almost limited to water, the chief facts bearing upon the type are the different horizons in the water, the lamellibranchs being buried beneath the surface of the bottom, the gastropods crawling over this surface, the cephalopoda swimming.

The classes would seem to owe their division into the secondary groups usually called orders, to facts of environment which owe their special importance to their connection with the special structure of the class. As an example of this, the mammalian type being developed with masticating teeth and narrow mouth and prehensile fore-limbs, foods assumed the first importance in the formation of mammalian orders, though of but little value in classes with wide mouths and non-prehensile fore-limbs.

Facts of environment, which were of primary importance in the formation of classes, may appear again in a secondary way in the division of classes into orders, and this even to the extent of antagonizing the class fact. Examples: bats, seals and whales, swimming and wading birds.

These primary facts may appear again and again until they may become the modifying fact with a species or variety.

Orders would seem to be usually divided into families and families into genera, etc., upon the same general ground as classes are divided into orders. Each group would, from its special structure, come into peculiar relations to a special set of facts. An example of this is found in the order Rodentia, fitted especially for hard foods. This order would be influenced in its division into families by the different locations of the general Rodent food and by the secondary divisions of the food itself, made upon its character. Such families as the Sciuridæ, Leporidæ, Muridæ, etc., result.

The characteristics of any given animal will consist of its type or branch character, plus all the characters gained by it in becoming fitted to the various facts concerned in forming its class, order, family, etc.

ORGANIZATION AND DEATH. By Dr. CHARLES SEDGWICK MINOT, Harvard Medical School, Boston, Mass.

[ABSTRACT.]

IN a communication presented last year it was shown that the organism, whether plant or animal, undergoes progressive decay, which begins probably at the moment of its creation. The object of the present paper is to point out that the decay and organization of the individual proceed *pari passu*, and that whenever development is begun the tissues always assume the undifferentiated and embryonic form. This is shown to be the case in all Metazoa, so that a correlation is established between the degree of organization and the rate of growth, and hence is established the hypothesis that organization stops growth, or in other words, causes the decay of the organism, and hence perhaps death. Death may then be the price of organization and the lowest organism may, perhaps, never have natural death.

A NEW MEMBRANE OF THE HUMAN SKIN. By Dr. CHARLES SEDGWICK MINOT, Harvard Medical School, Boston, Mass.

[ABSTRACT.]

IN the human fœtus there is a layer of large cells outside the horny layer and entirely distinct from it. This layer is homologous with the epitrichium of the Sauropsida, and covers also the hairs and glands. Its presence probably accounts for the retention or the sebaceous secretion to form the so-called *vernix caseosa*.

THE STRUCTURE OF THE HUMAN PLACENTA. By Dr. CHARLES SEDGWICK MINOT, Harvard Medical School, Boston, Mass.

[ABSTRACT.]

THE human placenta consists of: 1, the amniotic epithelium; 2, the amniotic connective tissue; 3, the stroma of chorion; 4, the cellular layer; 5, the fibrine layer; 6, the villi; 7, the chorionic epithelium, and 8, the serotina.

The structure and origin of these layers were described in detail. It was further shown that there is no intergrowing of the maternal and fœtal tissues, and that the placenta is mainly fœtal, and the intervillous spaces bounded only by fœtal tissue.

MORPHOLOGY OF THE SUPRA-RENAL CAPSULES. By Dr. CHARLES SEDGWICK MINOT, Harvard Medical School, Boston, Mass.

[ABSTRACT.]

BALFOUR and his scholars have maintained the theory of the double origin of the supra-renals. Examination of the human fœtal capsule renders it difficult to accept this view since the whole structure is similar throughout. There are masses and cords of cells, which are in radial lines externally but more irregular internally, but the cells of the cortex and medulla, both present in a six months' fœtus a similar and very remarkable appearance, so that it is difficult to admit that they are two distinct tissues of two distinct origins. The histological character of the parenchyma was described and illustrated in detail. Blood vessels run down from the cortex in nearly straight lines and perpendicular to the surface of the organ, but forming occasional anastomoses. In the medullary portion the blood vessels, which are continuous with, and of the same character as those of the vortex, run irregularly. The spaces between the vessels are all filled chiefly by supra-renal cells, and there is no possible demarcation. The medullary cells are unlike the cortical; but earlier the cortical cells have the same character as the medullary, being large and irregular in size. The change into small cells begins peripherically and spreads towards the centre, and ultimately the cells of the medulla also alter becoming like the previously changed cells of the cortex.

With a knowledge of these facts it becomes impossible to accept Balfour's theory until the difficulties it now encounters shall have been obviated.

EVOLUTION OF THE LUNGS. By Dr. CHARLES SEDGWICK MINOT, Harvard Medical School, Boston, Mass.

[ABSTRACT.]

THE object of this paper was to suggest that the lungs have been evolved by the modification of a pair of gill pouches, which do not break through in the neck, but grow down into the thorax.

This hypothesis is based upon the fact that the lungs arise directly behind the true gill pouches and in the same manner, as if they were serially homologous with the gills, and secondly upon the fact that the alveoli of the lung grow out very much as do the alveoli of the thyroid glands from the gill clefts from which they arise.

EXPERIMENTS ANTAGONIZING THE VIEW THAT THE SERRULÆ (SERRATED APPENDAGES) OF AMIA ARE ACCESSORY, RESPIRATORY ORGANS. By Prof. BURT G. WILDER, Cornell University, Ithaca, N. Y.

A PAPER[1] presented by me before this Association in 1876 contained the first figures and extended description of the serrated appendages of the throat of Amia with references to earlier notices of them.

I now propose to replace the English dionym by the Latin mononym *serrula* and to designate the cephalic or anterior by *præserrula*, the caudal or posterior by *postserrula*. The former is wholly attached to the skin; the latter is the longer and projects freely caudad for the greater part of its length.

In the paper just mentioned I expressed the belief that their flexibility and their relations to other parts afforded no ground for regarding them as performing any function, but that they are remnants of organs which were better developed and probably useful in some earlier form.

[1] See list at the end of this paper.

In 1884, Sagemehl suggested, upon purely anatomical grounds, that these appendages, which he named *flabella*, might be kept in constant motion and thus serve to aerate the water when insufficiently supplied with oxygen.

Later in the same year, my friend, Prof. R. Ramsay Wright from observations both anatomical and experimental, concluded that, in the absence of the ordinary, opercular, dilator muscles, the free end of the postserrula may serve to push the operculum away from the head so as to facilitate the escape of the respired water from the branchial cavity.

Notwithstanding my confidence in the accuracy of Prof. Wright's observations and my respect for his opinion, I have not felt satisfied with this disposal of the subject. With the coöperation of my colleague, Prof. S. H. Gage, and Mr. F. L. Kilborne, the following experiments were made in order to reopen the case and encourage further investigations.

Experiment 1, Feb. 26, 1885. A medium sized, vigorous Amia was rolled up in a wet towel. The left opercle was lifted with a finger and the free portion of the postserrula cut off with scissors. There was no bleeding or evidence of pain.

After the fish had regained its equanimity in water, a trained observer, who did not know what had been done, was asked to look at it from above and describe any difference that might exist between the opercular movements of the two sides. He said he was not sure there was any difference, but if either, the left opercle opened the wider; this was just the reverse of what would occur if it were pushed open by the postserrula and, so far as I could see, there was no difference at all.

The fish was then placed in a long jar of water which was held horizontally over the observer's head. During the exit of the water from the branchial cavity the right postserrula could be seen plainly; very slight movements were noticed, such as might be caused by the flow of water or the general action of the throat, but the postserrula *was never in contact with the opercle.*

Experiment 2, May 5, 1885. In order to expose the right postserrula completely and yet avoid even the appearance of a painful operation, the same Amia was placed on a wet towel in the anæsthetic box and subjected to the vapor of ether, 25 cc., and chloroform, 5 cc. Anæsthesia was complete in eleven minutes. In fifteen minutes more the fish was trephined between the eyes, the

prosencephal (cerebrum)removed and the orifice closed with a rubber cork. The opercular movements recommenced in six minutes after it was restored to the water and soon, but for the evident absence of volition and presumably of consciousness, the Amia was in its normal condition.

While resting quietly in water and apparently breathing naturally, the fish was carefully observed by thirteen special students. Seven thought the right opercle opened the wider, and six the left; none were very positive as to there being any difference.

The right opercle was then cut off with scissors. With each exit of the respired water there were the slight movements of the postserrula mentioned in experiment 1, but none which could possibly be supposed to either agitate the water or open the opercle, even were the postserrula stiff instead of yielding.

From the foregoing observations I conclude:

I. The opercular movements are wholly independent of the postserrula.

II. The serrulæ are atelec or functionless organs worthy of further embryological and palæontological enquiry.

Useful organs are common enough. The morphological significance of useless organs is so great that their number should not be diminished through error of observation or interpretation.

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AQUATIC RESPIRATION IN SOFT-SHELLED TURTLES (AMYDA MUTICA AND ASPIDONECTES SPINIFER); A CONTRIBUTION TO THE PHYSIOLOGY OF RESPIRATION IN VERTEBRATES.

By Prof. SIMON H. GAGE and SUSANNA PHELPS GAGE, Cornell University, Ithaca, N. Y.

[ABSTRACT.[1]]

IT was formerly supposed that in all reptiles the respiration was exclusively aerial at all periods of their life, and that the lungs were the only respiratory organs. We have demonstrated, however, that in soft-shelled turtles (Amyda and Aspidonectes) there is in addition a true aquatic respiration. This is *indicated* by three facts: (A) These turtles remain most of the time in water and voluntarily remain entirely under from two to ten consecutive hours; (B) while under water they fill and empty the mouth and pharynx, about sixteen times per minute, by movements of the hyoid apparatus, the general appearance being like the respiratory movements of a fish; (C) the mucous membrane of the pharynx is closely beset with filamentous processes, appearing like the villi of the small intestine of a mammal or the gill filaments of Necturus. These processes are especially numerous along the hyoid arches and around the glottis, and are copiously supplied with blood.[2]

But neither the time the turtles remain under water, the forcing of water into and out of the mouth and pharynx, nor even the structure of the parts proves that aquatic respiration occurs. Final

[1] A preliminary paper upon the Respiration of Aspidonectes was presented to the A. A. A. S. by the senior author in 1883 and printed on p. 316 of the Proceedings (Vol. xxxii).

[2] So far as we know but two original observations—besides that mentioned in note one—have been previously made upon the Trionycidæ bearing upon the subject of this paper: (A) In Feb., 1856, Dr. A. Sager called attention to the processes in the pharynx of Aspidonectes and compared them in appearance with the gill filaments of Necturus and the inner gills of Tadpoles. (B) Prof. L. Agassiz in part second of the "Contributions to North American Zoölogy," p. 284, says: "Before reading this paper [Dr. Sager's] we had noticed these organs [processes in the pharynx]; but after seeing this turtle [Aspidonectes] remaining under water for full half an hour without showing the least sign of oppression it seems plausible to assume that these fringes may be similar to the internal gills of Tadpoles, not only in their shape but also in their function. There exists, moreover, an extensive network of beautiful vessels spreading in elegant dendritic ramifications upon the whole lower surface of the Trionycidæ which can hardly have another function than that of assisting in the process of breathing, as they are too numerous and too large to be considered simply as nutritive vessels of the skin. This is the more probable as these vessels are very superficial and are only covered by a very thin epidermis. They are indeed as plainly visible through the horny layer which protects them as the vessels of any special external breathing organ...."

proof of this is only obtained by comparing the free gases found in water with those found in water from the same source after a turtle had been submerged in it without access to air. Water so tested showed in one case that a turtle weighing one kilo. in ten hours removed from the water 71 milligrams of free oxygen and added to it 231 milligrams of carbon dioxide. Several other determinations were of the same conclusive character.[3]

This indicates a respiration, for the same body weight, about one-twentieth of that occurring in man.

As indicated by the figures given above, the carbon dioxide is greatly in excess of what could be accounted for by the free oxygen taken from the water. There are two sources from which the extra oxygen might be derived: (A) From the so-called intramolecular oxygen stored up in the tissues, and (B) from the air in the lungs. Analysis of the air taken from the lungs after the turtle has been wholly submerged for ten hours showed only a slight trace of either oxygen or of carbon dioxide. From this single experiment then, we should conclude that if the lungs were moderately filled with air upon the immersion of the turtle, the amount of oxygen that might be taken from the air in the lungs would fully account for the excess of carbon dioxide found in the water. That the respiration is due almost entirely to the pharynx and but slightly to the skin is shown: (A) by anæsthetization, the turtle becoming anæsthetized four or five times as quickly when kept entirely submerged in etherized water as when allowed to come to the surface as frequently as it desired; (B) when the

[3] The following table shows the results of three analyses. In the first column is given the total amount of free oxygen taken from the water (10 litres) in the ten hours by a turtle weighing 1 kilogram. The second column contains the quantity of carbon dioxide that could be formed from this oxygen; and the third column contains the actual amount of carbon dioxide added to the water by the turtle, the excess of which, over the amount that could be formed from the oxygen taken from the water, is given in the fourth column.

	O.	CO_2.	Actual CO_2	Excess CO_2.
July 11 .	71 mg.	97 5-8 mg.	231 mg.	133 3-8 mg.
Aug. 8 .	32 "	44 "	212.7 "	168.7 "
Aug. 9 .	39 "	53 5-8 "	168.7 "	115 3-40 "

The determinations were made with the greatest care and accuracy by Professors Rich and Holton in the chemical laboratory of Cornell University.

turtle's skin was completely covered with vaseline and the turtle kept wholly submerged, the amount of oxygen removed from the water and of carbon dioxide added thereto was nearly as great as when the skin was unvaselined.

In some, at least, of the hard-shelled turtles (Chelydra and Chrysemys) similar movements of the hyoid apparatus occur when they are submerged, and water was seen to enter the nostrils and be expelled therefrom as in soft-shelled turtles.

The pharynx expands and contracts with considerable regularity in all of the turtles, so far as we know, when they are in the air. These movements appear like those of the frog, but they are unnecessary for filling the lungs. In frogs, however, they are necessary for this purpose, although, as shown by Townson (1794), the pharyngeal movements often occur in frogs without any air being forced into the lungs.

As these movements are of undoubted use in respiration for the soft-shelled turtles in water, it seems probable that they may be of use in respiration for all turtles in the air; that is, the membrane lining the pharynx probably acts as a respiratory organ whether the medium bathing it and containing free oxygen be air or water.

These movements and their object, respiration, then seem to connect, physiologically at least, the turtles on the one hand with the lower vertebrates, amphibia and fishes, and on the other hand with the higher forms, viz., dog and man, for Garland has shown that in the dog and also in man occur rhythmical pharyngeal movements which draw air into the pharynx and expel it whenever there is a condition approaching asphyxiation. It seems as though these pharyngeal movements reappear in the highest forms when the want of oxygen becomes overwhelmingly great, as if there were an organic memory of the means by which, in the dim past, the want was supplied.

BIOLOGICAL DEDUCTIONS FROM A COMPARATIVE STUDY OF THE INFLUENCE OF COCAINE AND ATROPINE ON THE ORGANS OF CIRCULATION. By Dr. H. G. BEYER, U. S. Navy.

[ABSTRACT.]

THESE deductions are considered of sufficient importance to be brought before you, for the reason that they touch upon the com-

plex, but deeply interesting and instructive problem of the innervation of the vertebrate heart. The heart is a compound organ consisting of muscular, nervous and connective tissue. No study of the action of any drug upon the heart can be considered complete, unless the nature of the action of such a drug upon each of these different elements composing the heart is clearly made out. The extreme difficulty of this problem, however, is very apparent to you, even without my attempting to go into the historical details of the controversy between the best physiologists with regard to the action upon the heart of even the best known drugs. With regard to the action of atropine upon the heart, it is the opinion of Schmiedeberg, Harnack and others that it produces paralysis of the vagus endings within the heart, thus causing acceleration and augmentation; muscarine, in their opinion, stimulates these same nerve-endings, thus producing diastolic arrest.

Bowditch, as long ago as 1871, and more recently Gaskell and Ransom have come to the conclusion that atropine stimulates the muscular substance and that the augmentation it produces on the heart's action is due to that influence and not to a paralysis of the vagus endings. Recently, Amalie Glouse, in her inaugural thesis, gives an account of some experiments, made in the laboratory of Professor Luchsinger at Born, which tend to prove almost conclusively that muscarine paralyzes the heart-muscle, instead of stimulating the vagus endings, and that, therefore, the diastolic arrest it produces is due to its paralyzing influence on the cardiac muscle and not to its stimulating influence on the vagus endings. In other words, the antagonistic action of atropine and muscarine with reference to the heart, according to Schmiedeberg, Harnack and others is a purely nervous phenomenon, while, according to more recent and equally good observers, it is a purely muscular phenomenon. From our last winter's work on the action of cocaine, atropine and muscarine on the heart, we are enabled to add some further proof to the muscular nature of the action of these drugs on the heart, and at the same time, perhaps, also succeed in indirectly showing that atropine and cocaine, instead of paralyzing the vagus endings, slightly stimulate them.

Upon the first admission of atropized blood into the isolated heart of the frog or terrapin, the heart-muscles preëminently manifest the action of some powerful stimulant. After a while, however, there arrives a stage of muscular exhaustion from overstim-

sufficient to

prove decisive, but, taken in conjunction with the experiments briefly alluded to, they form a sort of crucial test.

We may now formulate our conclusions about as folllows, viz.: muscarine paralyzes the cardiac muscle, atropine stimulates the same; atropine furthermore has a slight stimulatory effect upon the vagus endings and also on the endings of the accelerator- or augmentor-nerves of the heart. Cocaine affects the nerve-endings within the heart in the same manner as atropine does, but unlike the latter has no stimulatory action on the muscular substance of the heart.

THE STRUCTURE OF GLOTTIDEA PYRAMIDATA (STIM.) DALL. By Dr. H. G. BEYER, U. S. Navy.

[ABSTRACT.]

GLOTTIDEA PYRAMIDATA Dall was originally described by Stimson under the name of *Lingula pyramidata*. Dall found that it was not a true Lingula of which latter genus he says, no specimens are found in American waters. For various reasons, he gave it the name of *Glottidea pyramidata*.

1. *Shell-structure*. This consists, as in the true Lingulas, of alternating calcareous and horny layers and a thin cuticular covering, formerly called *periostracum*. In both transverse and longitudinal sections we find that the horny layers of the shell are continuous with the supporting layers of the mantle and body-wall respectively and that the calcareous layers are structurally continuous with the ectodermal layers of these two organs. The calcareous layers, therefore, have probably arisen from the original ectodermal covering and the so-called horny layers are true supporting substance. Both horny layers of the shell, and supporting substance of mantle and body wall, stain alike and with equal intensity. Embedded within the substance of the horny layers, we find a very large number of very small but well defined, round, little globules identical in appearance, described as occurring in the shell structure of testicardine brachiopods, in which, however, they are confined to the vertical septa, which, in these, start directly from the supporting substance of the mantle and body-wall respectively. The conclusion to which we have come with regard to these globules, and the horny layers, was, therefore, very near, namely, that

ulation, and, at the same time, there appears a peculiar dissociation of rhythm between auricles and ventricles. The auricles contract twice or three times to the ventricles once and quite independently of each other.

The dose of the drug may be so graduated that this peculiar rhythm is kept up for any length of time and, after the heart has recovered under normal blood, it can be reproduced many times during the course of one single experiment. How are we to explain this singular phenomenon?

In one of the Paris hospitals, in the service of Professor Boudet, a patient came under observation who had a radial pulse of twenty-one beats per minute, the auricles beating at the rate of sixty-three per minute. Professor Chouveau took a sphymographic tracing of this patient and went to work investigating the pathogeny of this condition. By dividing one of the pneumogastrics in a dog (?), he obtained some dissociation of rhythm; but, by slightly stimulating with a galvanic current, the left pneumogastric, he obtained a sphymographic tracing almost identical with that which he had taken from his patient. I think, therefore, that it is not at all improbable that the dissociation in rhythm produced by atropine is due to a slight stimulatory action which it exerts on the vagus-endings and which becomes apparent after the muscular substance has begun to show signs of exhaustion. Now, cocaine produces the same dissociation of rhythm, but, unlike atropine, cocaine produces it almost at once, for the latter does not possess any stimulating properties on muscular tissue. The sympathetic nerve-endings are equally stimulated by these two drugs, since the work done by the heart, at this stage of comparative muscular exhaustion and lowered ventricular rhythm, is still much greater than under normal conditions.

If muscarine produces cardiac diastolic arrest through its paralyzing influence on the muscular substances, and atropine and cocaine affect the heart in every respect alike, except that cocaine does not stimulate the muscle, then muscarine must produce diastolic arrest in the cocainized heart, although it does not so in the atropized heart. Muscarine invariably produces diastolic arrest in the cocainized heart, and here we have another proof of the muscular nature of the atropine-muscarine antagonism as manifested by the heart.

These experiments alone would, of course, not be sufficient to

prove decisive, but, taken in conjunction with the experiments briefly alluded to, they form a sort of crucial test.

We may now formulate our conclusions about as folllows, viz.: muscarine paralyzes the cardiac muscle, atropine stimulates the same; atropine furthermore has a slight stimulatory effect upon the vagus endings and also on the endings of the accelerator- or augmentor-nerves of the heart. Cocaine affects the nerve-endings within the heart in the same manner as atropine does, but unlike the latter has no stimulatory action on the muscular substance of the heart.

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they are homologous if not analogous with the vertical septa of testicardine brachiopods.

Body-wall, *Mantle* and *Peduncle*. A general uniformity obtains in the structure of these three organs. Three different layers may be readily distinguished in all of them, namely: An outer ectodermal covering, a middle layer of supporting substance and an internal layer of lining or peritoneal epithelium. The ectodermal layer is made up of small cuboidal cells of a homogeneous protoplasm in which lies embedded, an oval and comparatively large, well-stained nucleus. The supporting substance is either homogeneous or presents a very finely longitudinally striated appearance. The peritoneal lining epithelium consists of flattened, polygonal, nucleated cells joined edge to edge to form a membrane. All three, however, undergo important modifications according to situation and these will be again referred to in speaking of the remaining organs of the animal.

Alimentary canal. This consists of three layers throughout its whole extent. (1) An *external layer* of a very loose supporting substance which is covered with peritoneal epithelium and always associated very closely with numerous blood corpuscles or blood lacunes of various sizes.

(2) A *middle layer* consisting of very minute cells, very little differentiated.

(3) An *internal layer* of long and very narrow ciliated cells. The mouth is a flattened funnel shaped organ lying between ventral valve and the large œsophageal blood-lacunes, its opening looking in the direction of the peduncle or towards the inner surface of the ventral valve. The lower lip is crowned with a row of tentacles. The mouth, together with the œsophagus, forms a sort of horn-like projection through the anterior body-wall, the convexity of which would form the most anterior extremity of the alimentary canal, the larger end the mouth the narrow end joins the sacculated stomach within the body-cavity. Five broad canals are in direct communication with the stomach and leading from it into the blind pouches called liver lobules. Below the stomach the intestine is continued to the most posterior extremity of the body cavity, where it forms a loop or sometimes also merely bends on itself, after which it ascends on the right side and close to the ventral valve between the lateral body wall and the right oviduct up to the anterior body wall which it pierces to open to the exterior.

Muscular system. All the muscles of *Glottidea pyramidata* belong to the *non-striated* variety. The posterior occlusor muscle, which has been found to be striated in testicardine brachiopods, forms no exception to this rule in this animal. With regard to all those muscles which have been described in almost all existing brachiopods as parietal muscles and muscles of the peduncle, we have come to the conclusion, that they are not muscles at all but that the groundwork, at least, of these structures is made up of a mesenchymatous supporting substance which, however, may be possessed of a certain amount of contractility.

Vascular system. No central propelling organ of circulation, nor a closed system of bloodvessels with proper walls of their own, such as Hancock has described as occurring in other brachiopods, has been found to exist in this animal. There are, however, two oblong, pyriform, sack-like structures, situated on either side of the œsophagus and having rather thinner walls than the other blood-lacunes, which organs might possibly function as hearts, but, having thus far been able to study them from sections only, a positive opinion as to that must be withheld. They extend alongside the œsophagus up to the roots of the arms into which they seem to empty themselves and are always found crowded with blood corpuscles. The blood corpuscles are usually found in spaces hollowed out of the supporting substance, and within the body-cavity they are simply surrounded by the peritoneal membrane.

The Nervous System, in this animal, is subectodermal and consists of five large ganglionic accumulations. These, from their respective situations, have been named (1) the *large central subœsophageal*, (2) the two *ventro-lateral*, and (3) the two *dorso-lateral* or *supraœsophageal* ganglia. The commissure which joins the two ventro-lateral ganglia to the two dorso-lateral, is a double one, one branch of which passes on the dorsal side, the other on the ventral side of the arm root. These ganglia are made up of comparatively large multipolar ganglion cells, their processes anastomosing with those of neighboring cells; their nuclei are usually round and stain very much deeper than is the case with the protoplasm forming the cell-structure which is either very firmly granular or homogeneous.

Genital organs. With regard to these, the results of my studies have led me to differ essentially from the opinions of the best

and most modern writers on this subject. I think, I have discovered in *Glottidea pyramidata* an organ which, though never before described as existing in any other brachiopod, may nevertheless exist in them, but which has been overlooked. This organ is the testicle. It is found closely associated with the internal surface of the lateral body-walls on both sides, in fact the so-called spermatophores are developed from the peritoneal epithelium which lines the spongy, mesenchymatous network of supporting substance adjacent to the lateral body walls and covering them, on the side of the body cavity, like a semi-oval pad. It is from this organ that spermatophores are exclusively developed. Contrary to what has been found in other ecardine brachiopods, in Glottidea we have genital glands present in the mantle-sinuses, but here both spermatophores and ova are developed side by side, while within the body cavity; the spermatophores spring from the lateral body-walls, while the ova are developed from the peritoneal epithelium covering the mesenteric bands and their reflected portions; the latter occupy therefore a much more central position than the spermatophores do, with relation to the animal. Glottidea is an hermaphrodite animal with both female and male organs of generation united within the same individual, although it is a rare occurrence to find both in equal proportions and equally well developed at the same time.

OBSERVATIONS ON THE MUSKRAT. By AMOS W. BUTLER, Brookville, Ind.

[ABSTRACT.]

THE muskrat (*Fiber zibethicus* Cuv.) is very abundant in most localities in southeastern Indiana. In local distribution it varies in numbers according to the abundance of water and favorable localities for its increase. It is probably not less common than at the time of the settlement of this region.

These animals soon become accustomed to man and to his protection, as well as to the rapid diminution of their natural enemies, on account of his necessity and pleasure. Originally, they had their homes in the neighborhood of natural watercourses, but with the system of state improvements which led to the building of our canals, there came, in many localities, a change in the life of

the muskrats. Upon the completion of "The White Water Valley Canal," in 1846, the greater number of muskrats living upon the streams, along which it ran, sought this artificial water way and there established homes. At the present time, along that portion of the canal in existence, but few muskrats have sought the neighboring streams whence their ancestors came. When the canal through this part of the state was destroyed in 1866, the rats disappeared from many places where they had long found a home. Some sought the rivers whence their ancestors came; others gathered into certain parts of the old canal bed which were not permitted to remain unused. One of these portions extending from Laurel to Brookville, a distance of fifteen miles, is now the property of "The Brookville and Metamora Hydraulic Company." Here it is that I have become best acquainted with this water-loving rodent.

The muskrat prefers its home in banks of loam or light clay, but rarely occupies gravelly banks. It is owing to this that the gravel banks of the railroad and of the canal when kept free from vegetation are rarely bothered; while those of loam are generally honeycombed by the passages of this industrious mammal. With the alternate freezing and thawing of early spring, the coverings of these passages fall in, exposing cavities of surprising extent. It is only by vigilant watching at this time that property owners are saved great loss.

The underground homes of the muskrat in the banks of the canal have each two openings, from eighteen inches to two feet apart. The top of each hole is just on a line with the top of the water at its low and high stage respectively. The passages from these openings lead backward and upward in a very crooked way, ending in a large gallery which is the home of the animal; from the latter a passage is sometimes found leading to the surface where it appears as an "air hole." The depth to which these underground passages penetrate the banks varies; the minimum depth attained being about five feet; the maximum, thirty feet.

In the abandoned parts of the old canal, before referred to, the muskrat built houses for the first time in this part of the state. They were few in number and were confined to wet tracts in the old canal bed and swamps adjacent thereto. Until within the past three years no houses have been built along the water-power canal between Laurel and Brookville. Each year a few more have

been added to those completed at that time until now there may be seen a dozen or more within the fifteen miles just mentioned. Whether house-building muskrats from farther to the northward have entered this region and found others of their kind who could appreciate homes of their own erection, or whether the representatives in this locality have taken upon themselves this much of the ways of some ancestor, I know not.

There is much regularity in the general form and interior arrangement of these houses, but in size and material used in construction there are great differences. The muskrat generally chooses one of the higher parts of a piece of marshy ground and then excavates a circular or oval-shaped hole to the depth of the surrounding water, after which he constructs a building of the following kind (which is typical of this locality); the house is composed of swamp grass, sedge, coarse weeds, mud, fresh water algæ and a few pieces of drift. The ground plan is oval in outline, four feet, six inches wide and six feet, three inches long; on the land side the house is two feet, six inches high and next to the water three feet, four inches. The whole presents the appearance, in miniature, of an oblong hay rick. The inside is quite irregular, being from sixteen to twenty-two inches in length and about twelve inches in average width with a height of one foot. Six inches from the bottom a shelf of eight by twelve inches is found running to the left of the entrance; an arched chamber is formed above the shelf. Entrance to the house is had by means of a tunnel of mud and weeds which leads from the exterior beneath the water to the centre of the chamber, where access is had by a funnel-shaped opening in a mass of material similar to that of which the house is built.

These houses are only occupied during cold weather, the animals spending the greater part of the year in their sinuous cavities in the neighboring banks. In this vicinity I think but one brood is brought forth in a year. Occasional exceptions may be noted, but I believe the rule will hold good. Mating takes place late in February or early in March and continues about three weeks. The period of gestation is about six weeks. In April or early May the young are brought forth, from four to six helpless and hairless little creatures, and remain in the nest until they are about half grown.

Muskrats feed upon both land and water plants, using in many

instances, roots, stems and fruit alike. Corn is their great vegetable food and for the love of this cereal many of their number are killed each year by the farmer and his allies. The greatest damage is done to the corn after the ear is well formed or in "roasting ear." They also like parsnips, turnips and apples. In winter and in early spring the muskrats often take to a diet of animal food; at such times the meat of some species of fresh water mussels affords them their chief supply. They do not confine themselves to the flesh of living animals, the remains of geese, ducks, chickens, fish, and, in one instance, a turtle forming a part of their food. Muskrats sometimes eat the dead of their own kind.

The muskrat is largely nocturnal in its habits. On cloudy days and occasionally late in the afternoon one may be seen, along some quiet stretch of water, seeking food or looking for its mate. It is not much at ease on land, although when pursued it moves over the ground at an ambling gait with some degree of rapidity. It is an expert at swimming and diving. In open water it dives to a considerable depth, and I have noticed it passing through shallow water apparently running upon the bottom. It appears disinclined to dive in muddy water.

A number of ways are employed to kill these animals. Steel traps are a common instrument and are very effectual; a dead fall is sometimes used, as are also poisoned apples or turnips which are placed in the neighborhood of their burrows. A local water power company make use of a barrel, with both heads knocked out, which is placed along the bank of the stream with about half its length out of water. Upon the water in the interior of the barrel is placed some light vegetation and upon the latter some pieces of parsnip or turnip as bait. In the animal's efforts to get the coveted vegetable it is sure to get into the barrel; the water is too deep for it and it is only by standing upon its hind legs that it can sustain life. Within the mating season it not unfrequently occurs that a female is the first one caught and in their efforts to become her company as many as nine of the opposite sex have been known to be caught in the same barrel. When several are caught at a time a terrific fight is almost certain to follow, ending in the death of most of the contestants and in the destruction of the skins so far as value is concerned. Of the enemies of the muskrat man ranks first, and next to him the dog. Hawks and owls of the larger species, foxes and minks are all very destructive to this an-

imal. The muskrat is, at times, very ferocious. When cornered by dogs or man it frequently shows fight and if closely pressed is able to do much execution with its sharp teeth.

The above facts have been gathered while endeavoring to trace some of the faunal changes that have occurred in Indiana.

THE PERIODICAL CICADA IN SOUTHEASTERN INDIANA. By AMOS W. BUTLER, Brookville, Indiana.

[ABSTRACT.]

IN the locality where the observations mentioned in this paper were made, Brookville, Ind., the Cicada had not been previously studied.

Reliable evidence was found of its occurrence in that vicinity, prior to this, in 1834, 1851 and 1868. This year it was reported from the counties of Dearborn, Decatur, Rush, Union, Ripley, Franklin, Fayette, Wayne and Delaware; the latter, however, not within the district contemplated in this paper. The regularity of its appearance is surprising. On the past three visits the earliest date at which it was noticed was May 24th, the latest May 29th. Three days after appearing they began giving utterance to their peculiar notes, and seven days later appeared to be in full song. Eight days after appearing mating began, and appeared general in five days more. In eighteen days from the date of its appearance ovipositing was commenced. A double chambered egg cavity was made in the limb of a tree, by means of the two small saw-like organs of the females; into these cavities the ovipositor was inserted and two eggs were probably deposited at a time, each at the same angle with the partition wall. The openings of these egg cavities were from $\frac{5}{16}$ to $\frac{1}{2}$ inch in length and were about the same distance apart. Sometimes but two or three punctures were made on a limb but, in some instances, the number ranged from thirty to forty, and even above the latter number. No limb over $\frac{1}{2}$ inch in diameter has been found punctured. Of about forty species of trees and shrubs examined, fifteen appeared to be specially selected by this insect as suited for receiving its eggs. Seven species were rarely occupied, and upon two species no evidence of cicada occu-

pation could be found. Twenty-three days after the appearance of the cicadas the males, which came first, began to disappear; nine days later but few cicadas could be found and these were mostly females. Thirty-nine days after appearing only an occasional representative of the species could be found.

The typical species *Cicada septendecim* L., and its variety *Cassini* Fisher, were both found here, but the latter much the more commonly. They do not frequent the same territory. Three different sounds are produced by the cicada. Two of them are common to both forms while in the third they are different. The sounds appear to be produced as follows: the abdomen is inflated with air, then, by contraction the air is forced against the corrugated membrane forward of the abdomen which, by alternate expansion and contraction, as permitted by the controlling muscles, give forth the sounds. Toward the latter part of their lives the cicadas become affected by a peculiar fungus growth which gradually takes possession of the entire abdominal cavity causing the insect to drop to pieces while the animal is yet alive. Both sexes are affected by it but it is found most frequently in the males. Those which do not meet a violent death at the hands of their enemies are in a great part killed by this parasitic growth. Eight species of birds were found to be very destructive to the cicada. The one which killed the greatest number was the English sparrow, *Passer domesticus* Leach. Of thirty-three species of birds examined, all but two were found to contain cicada remains. Fox squirrels, *Sciurus niger ludovicianus* Allen, and ground squirrels, *Tamias striatus* Baird, destroyed great numbers of them. Fish of various species ate those which fell into the water. Of species examined the black bass, *Micropterus salmoides* Henshall, blue cat fish, *Ichthœlurus punctatus* Jor., and white sucker, *Castastomus teres* LeS. were found to have eaten them. Two species of land shells *Mesodon exoleta* Binn. and *M. elevata* Say, were found feeding upon the dead bodies of cicadas. Aside from the damage done young trees in nurseries and orchards their coming was productive of little or no loss. Undoubtedly, these insects appear in fewer numbers at each septendecimal visit. That this decrease in numbers cannot always continue is very evident and at some time in the future it is probable the cicadas will have entirely disappeared from this portion of our country at least.

THE SONG NOTES OF THE PERIODICAL CICADA. By Prof. C. V. RILEY, U. S. Entomologist, Washington, D. C.

[ABSTRACT.]

THERE are few more interesting subjects of study than the notes of insects and the different mechanisms by which they are produced. From the day when Aristotle discoursed upon them they have interested every observant entomologist. It is difficult to record them in musical symbols that can be reproduced on musical instruments, some of the more successful and interesting attempts in this direction having been made by Mr. S. H. Scudder. I have studied closely the notes of a number of species and have published some of the observations. [1]

In the notes of the true stridulators, more particularly, as the common tree crickets and katydids, I have been impressed with the variation both in the pitch and in the character of the note, dependent on the age of the specimen and the condition of the atmosphere, whether as to moisture, density or temperature. Yet with similarity in these conditions the note of the same species will be constant and easily recognizable.

A few remarks upon *Cicada septendecim* will doubtless prove of interest since the species has this year occupied so much attention. I do not find that the notes have been anywhere very carefully described in detail; nor would I pretend to put them to musical scale. Writing seventeen years ago I described the notes in a general way as follows: "The general noise on approaching the infested woods, is a compromise between that of a distant threshing machine and a distant frog pond. That which they make when disturbed mimics a nest of young snakes or young birds under similar circumstances—a sort of scream. They can also produce a chirp somewhat like that of a cricket, and a very loud shrill screech, prolonged for fifteen or twenty seconds, and gradually increasing in force and then decreasing." [2]

There are three prevalent noises which, in their blending, go to make the general noise as described above. These are:—

(1). That ordinarily known as *Phar-r-r-r-aoh* note. This is the note most often heard during the early maturity of the males and especially from isolated males or from limited numbers. It

[1] 3rd Rep. Ins. Mo. pp. 14, 153, 154; 4th do. p. 139; 6th do. pp. 150-169.
[2] 1st Rept. Ins. Mo. 1868, p. 24.

is variable in pitch and volume according to the condition just mentioned as generally affecting insect melodists. Its duration averages from two to three seconds and the *aoh* termination is a rather mournful lowering of the general pitch and is also somewhat variable in pitch, distinctness and duration. In a very clear atmosphere and at certain distances an individual note has often recalled that produced by the steam whistle on a fast train especially when about to pass under a tunnel. But when heard in sufficient proximity the rolling nature of the note will undoubtedly remind most persons more of the croaking of certain frogs than of anything else. I have heard it so soft and low and so void of the *aoh* termination that it was the counterpart of that made by *Oecanthus latipennis* Riley late in autumn and when shortened from age and debility of the stridulator.

(2). The loudest note and the one which is undoubtedly most identified with the species in the popular mind, is what may be called the screech. This is the note described by Fitch as: "represented by the letters tsh-e-e-E-E-E-E-E-e-ou, uttered continuously, and prolonged to a quarter or half a minute in length, loud and piercing to the ear, and its termination gradually lowered till the sound expires." Dr. Fitch errs as to the length of its duration and I have also erred in the same direction unless indeed there is a still greater range than my subsequent observations would indicate.[3] It is more probable, however, that our memories were at fault, for, as I have verified this year, this *shrill* ordinarily lasts from two to three seconds—though occasionally longer—and is repeated at intervals of every five seconds. This note is rarely made by solitary males or when but few are gathered together, but it is the prevailing note in the height of the season and is made in unison, *i. e.*, the assembled males on a given tree or within a given grove are prompted to it simultaneously, so that its intensity becomes almost deafening at times. It is of the same nature as that made by the dog-day cicada (*Cicada pruniosa* Say) and in its higher and louder soundings is not unlike the commoner shrill of that species, though by no means so continuous. It is what in the distance gives the threshing machine sound and it has often recalled that which I have heard in a saw-mill when a log is being cut crosswise by a circular saw.

[3] Since this was written I have heard on two occasions this note prolonged to 20 seconds, but this is very abnormal and I have no other evidence than the season (June 20th) that it belonged to *C. septendecim*.

(3). There is what may be called the intermittent, chirping sound, which consists of a series of fifteen to thirty, but usually about twenty-two, sharp notes sometimes double, lasting in the aggregate about five seconds. This sound is so much like that produced by the barn or chimney swallow (*Hirundo erythrogastra*) that a description of one would answer fairly well for both. It resembles also, though clearer and of higher pitch, the note of *Microcentrus retinervis* (Burm.) which I have likened to the slow turning of a child's wooden rattle highly pitched.

The above notes are, so far as I have observed them, of higher pitch though of less volume in the smaller *cassinii* form.

The other notes, viz., that made when the insect is disturbed and a not infrequent short cry that may be likened to that of a chick, are comparatively unimportant; but no one could do justice to the notes of this insect without describing the three peculiar sounds which I have attempted to describe above and which are commingled in the woods where the species is at all common, though the undulatory screech is by far the most intense and most likely to be remembered.

[The paper concludes with a description of the mechanism by which these various notes are produced, and after referring to the writings on this mechanism of Reaumur, Roesel, Solier, Landois and others, agrees with the earlier authors in considering the notes stridulatory rather than vocal. Riley believes that Landois, one of the last writers, who reversed the previous conclusions and asserted the notes to be vocal and due to the metathoracic spiracles, was essentially wrong. The noise produced is not made as is the buzzing Diptera as Landois concluded, for while the air passages act their part in modulating the vibrations, the source of the noises is found to be in the parchment-like and ribbed drums, a portion of which is made to vibrate with great rapidity by the strong V-shaped muscles located in the abdomen and which have great muscular power so that even after separation from the insect and when pressed with a point held in the hand, they produce such intense vibration that it may be likened to a galvanic shock.]

ON THE PARASITES OF THE HESSIAN FLY. By Prof. C. V. RILEY, U. S. Entomologist, Washington, D. C.

[ABSTRACT.]

THE paper consists of a digest of a communication on the same

subject now in press in the Proceedings of the U. S. National Museum. It gives the synonymy of *Merisus destructor* (Say), showing the difficulty that has been encountered in the past in properly locating the species generically. It then reviews what was known of the habits of the species by earlier authors and, on account of the insufficiency of previous descriptions, gives a full and detailed description. The descriptions of Herrick, Fitch and Packard are shown to refer to this species rather than to any other so far known. The species never occurs in the apterous condition.

Merisus (*Homoporus*) *subapterus* n. sp. is then described and separated from *destructor*, the wingless specimens referred to by Say and Herrick under this last species being considered as belonging to *subapterus*. *Subapterus* is, exceptionally, winged. *Destructor* is, on an average, of smaller size, more uniformly metallic in color; has a flatter abdomen with yellowish spot at base; has the antennæ similar in both sexes and either pale brown or blackish-brown; has the coxæ metallic black, the femora brown or black except towards tip, the paler parts of the legs whiter than in *subapterus*, and does not, so far as we now know, occur in the apterous condition.

Subapterus is, on the average, larger; of darker color and less metallic, with the flagellum of the antennæ pale in the male and black in the female; the abdomen much more rounded and without the pale spot; the coxæ, trochanters, femora and basal part of tibiæ honey-yellow. It occurs mostly in the wingless condition.

The paper next treats of *Eupelmus allynii* French, showing that it is parasitic on both *Isosoma hordei* and *I. tritici* as well as on the Hessian fly. The phytophagic habit of this genus is then shown and the experience of the author is given in breeding species from Lepidopterous eggs, from Orthopterous eggs, from Hemipterous eggs, from Cynipid galls, from Lepidopterous larvæ, from Coleopterous larvæ and from free Cecidomyid larvæ.

Tetrastichus productus n. sp. is described and the inference drawn from the habits of the genus that it may be a secondary parasite.

Platygaster herrickii Packard is then treated of with the conclusion that *P. error* Fitch is parasitic on some other insect and not on the Hessian fly. The statements of both Herrick and Prof. A. J. Cook are then considered in reference to the oviposition of this species in the eggs of the Hessian fly. The author, while disinclined to oppose direct observations when asserted, even when

such conflict with all that has before been known or with universal rule, still feels that the observations need verification and that it is probable that both Herrick and Cook mistook the young Hessian fly larvæ for the eggs.

Another species of *Tetrastichus*, to which Prof. S. A. Forbes has given the MS. name of *carinatus*, is briefly referred to as being in all probability a secondary parasite, and a single *Microgaster* is mentioned which is not described, as some doubt exists as to whether it is parasitic on the Hessian fly, although bred from straw infested by this last.

SOME POPULAR FALLACIES AND SOME NEW FACTS REGARDING CICADA SEPTENDECIM L. By Prof. C. V. RILEY, U. S. Entomologist, Washington, D. C.

[ABSTRACT.]

AMONG erroneous notions, the author mentioned the prevalent ones that the variety *cassinii* Fisher represents the race *tredecim* Riley, and that the twigs to which eggs are consigned must necessarily break off or die to insure the hatching of the larva.

The author then gave a number of exact facts from recent observations in the life history of the species, both below and above ground.

ON THE CARAPAX AND STERNUM OF THE DECAPOD CRUSTACEA. By HOWARD AYERS, Ph. D., University of Michigan, Ann Arbor, Mich.

[ABSTRACT.[1]]

THE paper treats of the homologies of the parts of each of the cephalothoracic segments and attempts the solution of the problem of the origin of the carapax and sternum by adding a few observations to those given in the literature of the subject.

[1]To be published in full with illustrations in the Bulletin of the Essex Institute, Salem, Mass.

On the structure and function of the sphæridia of the Echinoidea. By Howard Ayers, Ph. D, Ann Arbor, Mich.

[ABSTRACT.[1]]

1. A decade since Lovén discovered that most species of the Echinoidea were provided with oval, club-shaped organs whose structure so far as he made out threw no light on the question of their function. This author describes the organs as made up of a calcareous body covered by a ciliated epithelium; the body consisting in his opinion of two sorts of calcareous matter (*a*) a "vitreous calcareous substance" forming the bulk of the body and (*b*) a "reticulated calcareous tissue" forming a network within the body substance. His observations resulted in the conclusion that these organs were confined strictly to this group; within this limit however every genus save Arbacia possessed them. These organs were considered as sense organs and called sphæridia.

2. From a study of these small bodies it became evident to me that the sphæridia were modified spines. This fact is hinted at by the structure of the organ especially the neck region, as well as by this development. They vary greatly in number on the test, with this species (*e.g.*, from 2 or 3 to 50). They are always confined to the ambulacral zones of the abactinal surface. They are variously arranged about the peristome: *e.g.*, in pockets, Schizaster, Brissus; in radiating lines, Strongylocentrotus, Echinus. They measure about one-half mm. in length and one-fourth mm. in diameter. Their movements are similar to those of the spines. They vary in form from club-shaped, oblong oval, and oval to nearly spherical.

In each sphærid are readily distinguished three regions, the base, the joint, and the body. The latter part is made up of the neck and head. The base is a mamelon on the test similar to those of the spines; the joint is composed of fibres and muscular tissue and connects the body to the base. The body is movable through the joint and is composed of a vitreous calcareous matter deposited in concentric layers, the "reticulate tissue" of Lovén is however a system of open canals. These canals in the living sphærid are filled with a lymph fluid which floats nerve cells in the lacunar spaces of the system and nerve filaments in the canalicular pas-

[1] Paper published in full in Quar. Journ. Mic. Sci., Oct. 1885, 1 pl. 23 fig.

sages. The canal system opens on the surface of the head in funnel shaped openings, and communicates through numerous holes in the bottom of the neck with the body of the animal. There is no regularity in the development or distribution of the canals in the body.

The calcareous globule is covered by a ciliated epithelium composed of relatively large cylindrical cells—whose relation to the enlarged nerve ends has not been satisfactorily determined. The nerve supply of each organ passes into it at the joint and occupies the spaces of the canal system.

Where these canals communicate the nerve cells are also structurally united and by this intercommunication form a network of nerve cells and filaments that send off radiating filaments to the peripheral epithelium where they end in a club shaped enlargement. These nerve ends recall similar structures described by Hertwig Bros. for some of the Medusæ and are found in no other part of the echinoid body so far as I am aware.

From numerous experiments instituted for the purpose of ascertaining the functions of these organs it seems certain that speaking in terms of vertebrate physiology we have to do with a compound function, *i.e.*, with the function of taste and smell combined, both in an undifferentiated state. The sphæridia have for their function the detection of those chemical and physical changes in the water which, in fishes for instance, would call for the exercise of the functions taste and smell.

ON THE STRUCTURE OF THE BRAIN AND AUDITORY APPARATUS OF A THEROMORPHOUS REPTILE OF THE PERMIAN EPOCH.[1] By Prof. E. D. COPE, Philadelphia, Pa.

THE following observations are made on a part of a skull of one of the Diadectidæ (Pelycosauria with transverse molar teeth[2]), which is accompanied by several vertebræ and other fragments of the skeleton of a single individual of undetermined species. A few

[1] The substance of this paper will be found in the Proceedings of the American Philosophical Society of October, 1883.

[2] For a definition of this family and the included genera, see Proceedings of American Philosophical Society, 1880, p. 45.

characters are derived from skulls of two allied species, *Diadectes phaseolinus* and *Empedias molaris* Cope, which, like the first named specimen, were derived from the Permian formation of Texas. A cast of the brain chamber was obtained, thanks to the skill of my assistant Mr. Geismar, first in the elastic material patented by Bendernagel & Co., of Philadelphia, for the manufacture of printers' inking rolls; and afterwards in plaster of Paris, in a mould made from the elastic cast.

The brain-case in the Diadectidæ differs from that of the Clepsydropidæ, much as that of the Varanidæ from those of other Lacertilia. That is, it is continued between the orbits so as to enclose the olfactory lobes of the brain within osseous walls. These walls are thin, especially at the interorbital region, and in the specimen the anterior extremity is so far imperfect as to leave the form of the anterior fundus in doubt.

The brain in reptiles, as is well known, does not fill tightly the cranial chamber, as is the case with Mammalia, there being a wadding of connective tissue, with interspaces filled with lymph and fat, between it and the cranial walls. In the present species the post frontal part of the cranium is so contracted that there could have been but little space of this kind, and the inferior walls are clearly impressed by the surfaces of the middle brain and the cerebellum. The form of the inferior surface of the brain posterior to the fifth pair of nerves cannot be determined from the specimen examined, owing to the absence of the basioccipital and basisphenoidal bones.

The conformation of the cranial walls requires preliminary notice. In the first place the vestibule of the ear can only have been separated from the brain by a membranous septum, as is the case in the *Protonopsis horrida*[3] (Menopoma). In clearing out the matrix no trace of osseous lamina could be detected on either side, and the edges of the huge foramen thus produced are entire, and present no broken edges. Anterior to the vestibule, the proötic bone has a small extension terminating in a vertical border. In front of this is the huge vertical foramen through which issues the trigeminus nerve, which is even larger than that found in the Testudinata and Crocodilidæ. The anterior border of this foramen is formed by

[3]See Journal Academy Philadelphia, 1866, p. 105, where the characters of the skull in the Urodela are pointed out.

the probable alisphenoid, whose posterior edge is nearly parallel with the anterior border of the proötic, sloping forwards as it descends. The basicranial axis is thin at their union on the middle line below and, thickening forwards, is excavated by rather small conical fossa. Anterior to the fossa is a smaller impressed fossa, and on either side of it each lateral wall is excavated into a shallow fossa which descends towards it. The fronto-parietal fontanelle is of extraordinary size.

1. *The Brain.*

When the superior border of the medulla oblongata at the foramen magnum is placed horizontally, the axis of the brain ascends at an angle of 45° towards the frontoparietal fontanelle. Its superior surface, anterior to the foramen magnum, is subquadrate in outline, the angles being truncated, and directed anteriorly, posteriorly, and laterally. A posterior constriction connects it with the medulla, the anterior with the middle brain hemispheres; and each lateral truncated angle represents the foramen of the trigeminus nerve. The space thus bounded is divided into two nearly equal areas by a transverse groove, which extends from the posterior edge of one of these foramina to the other. The posterior of these I suppose to represent the cerebellum, and the anterior the mesencephalon. The cerebellar surface indicates that, as in many lizards, the cerebellum is simple, and very slightly convex.

Anterior to the foramen trigemini the brain contracts so as to have a transverse diameter scarcely more than one-third its vertical diameter. The cast, at a point twice as far in advance of the cerebellar line as the fore and aft width of the cerebellum, rises to fill the frontoparietal foramen, forming a mass which represents the huge pineal sac, or epiphysis. The proportions of this body are even greater than they are in any of the existing Lacertilia, and it has a greater transverse diameter than the middle brain inferior to it. Its posterior border is at right angles to the line continued forwards from the superior border of the medulla oblongata at the foramen magnum. At its posterior base a flat horizontal process, as wide as the brain at this point, extends posteriorly in a corresponding fossa of the superior cranial wall. Its posterior margin occupies a transverse groove of the superior wall, between the superior and inferior plates. Each lateroposterior angle is produced, and

may represent the foramen of exit of a narrow canal which appears to perforate the lateral wall and issue beneath the roof of the temporal fossa. A larger projection of each side of the base of the epiphysial mass occupies a large foramen of the lateral wall, which has the superior wall for its superior border. This may only represent a vacuity of the wall, but the fossa at the posterior base of the epiphysis has greater significance. What this is I am at present unable to ascertain.

Below the epiphysis the transverse diameter of the brain is about one-fourth the vertical, not including a short inferior prominence. The latter is small and conical, and is situated below the centre of the epiphysis when the cerebellar surface is placed horizontally, or in front of it, when the medulla at the foramen is placed horizontally. Its significance is unknown to me, as it is anterior to the position of the hypophysis. A thickening of the cast on either side of its base converges to the median line posterior to it. I can find no optic foramina, and believe, therefore, that the optic nerves issued from the same large sinus as the trigeminus. The cast diminishes in vertical diameter anterior to the inferior conical process, and increases in tranverse diameter of its superior surface. The inferior border continues to be keel-like, so that a vertical section is triangular with the base superior. It is impossible to distinguish the outlines of the cerebral hemispheres or the olfactory lobes, both of which are probably included in this part of the cast, although the latter probably extended much anterior to the extremity of the brain-case as preserved. The form may or may not give an idea of the form of the hemispheres. In any case they were narrower than in any known reptile.

The prominent features of this brain are then the following: The widest part is at the origin of the trigeminus nerve. Both the cerebellum and mesencephalon are flat and simple. The hemispheres are narrower than the segments posterior to them, and of greater vertical diameter. The epiphysis is enormous, and sends a process posteriorly between the tables of the parietal bone, and the hypophysis is small. The olfactory lobes were apparently large, and had a greater transverse diameter than the hemispheres. The reduced diameter of the hemispheres is a character of fishes and Batrachia rather than of reptiles, but the mesencephalon is also smaller than is the case in Batrachia. The small flat cerebellum is rather batrachian than reptilian.

2. *The Auditory Apparatus.*

As already remarked, the internal wall of the vestibule is not bony, so that the cast of the brain cavity includes that of the vestibule also. On the external wall of the latter are the orifices of the semicircular canals. These are, one double fossa at the superior anterior part of the wall; a second double one at the posterior superior part of the wall, and a single orifice at the inferior posterior part of the wall. The external part of the vestibule is produced upwards and outwards to the fenestra ovalis. The "double fossæ" above mentioned are the osseous representatives of the membranous ampullæ at the junction of two pairs of semicircular canals.

On sawing open the periotic bones, which here form a continuous mass, the following is seen to be the direction of the semicircular canals: the superior canal is horizontal; the second canal from the posterior ampulla descends, and, after a course a little longer than that of the superior canal, turns posteriorly. The inferior canal from the anterior ampulla also descends, and after a shorter course than the canal last mentioned, also turns backwards and joins it, the two forming a single canal, which enters the vestibule by the single posterior foramen already described. The lumen of the longer perpendicular canal is much larger than that of the others. As its ampullar orifice is also the largest of all, I suppose this increased diameter to be partly normal; but it may be partly abnormal, as its walls are irregular and rough.

The fenestra ovalis is not preserved in this specimen, but can be seen in the crania of the species *Diadectes phaseolinus* and *Empedias molaris* above mentioned.[4] The vestibule or a diverticulum from it is produced upwards and backwards, and terminates in a round os. This clearly is not a tympanic chamber, nor is it a rudimental cochlea. It does not appear to be homologous with the recessus labyrinthi, since that cavity is not perforated by the fenestra ovalis. It appears to be a prolongation outwards of the vestibule and sacculus, which may be observed in a less degree in the genus Edaphosaurus (Cope), also from the Texas Permian formation. Here the adjacent bones are produced slightly outwards, and the fenestra ovalis is closed by a large stapes similar

[4] See skull of *E. molaris*, Proceedings American Philosophical Society, 1881, Plate v, figs. *a* and *b*, where the fenestra is represented.

in external form to the one I have described in the *Clepsydrops leptocephalus*. Its more intimate structure I have not examined.[5]

The result of this examination into the structure of the auditory organs in the Diadectidæ may be stated as follows: the semicircular canals have the structure common to all gnathostomatous Chordata. The internal wall of the vestibule remains unossified, as in many fishes and a few batrachians. There is no rudiment of the cochlea, but the vestibule is produced outwards and upwards to the fenestra ovalis, in a way unknown in any other family of vertebrates.

I may add, that in the specimen examined the semicircular canals were filled with a white calcareous powder, probably derived from the comminution of otolites.

THE PRESENCE OR ABSENCE OF UNDERBASALS IN CRINOIDS CAN BE ASCERTAINED FROM THE COLUMN. By CHARLES WACHSMUTH, Burlington, Iowa.

[ABSTRACT.]

IT can be ascertained from the position which the column occupies toward the general symmetry of the calyx; from the outer angles of the stem joints, their position, and that of the cirri, whether radial or interradial; and from the direction of the rays along the axial canal. The following rules prevail:—

1. In species with underbasals, whenever the column is pentangular, its longitudinal angles are directed interradially, the sides and columnar cirri, if present, radially; on the contrary, in species with basals only, those angles are radial, the sides of the column and the cirri interradial.

2. When there are underbasals and the column is pentapartite,

[5] Professor Owen has figured (Todd's Encyclopædia, Art. Monotremata) a structure in Echidna which looks remarkably like that here described. This is a tubular elongation of the meatus auditorius externus, with more or less cartilaginous walls. This structure might be regarded as homologous with that displayed by the Empedias, could we imagine that with their diminution in size in the Monotreme, the ossicula auditus had retreated within this tube, preceding the membranum tympani, from a position at its distal, to one at its proximal extremity. But such a supposition has as yet no foundation, and the similar parts in the two types may have no homology.

the five sections of the column are interradial, the longitudinal sutures radial, the angles along the axial canal radial; but the opposite is the case when there are basals only.

[For further particulars, attention is directed to Revision of the Palæocrinoidea Pt. III, Sections I and II, by C. Wachsmuth and Frank Springer, now in press.]

CŒNOSTROMA AND IDIOSTROMA, AND THE COMPREHENSIVE CHARACTER OF THE STROMATOPORŌIDS. By Prof. ALEXANDER WINCHELL, University of Michigan, Ann Arbor, Mich.

[ABSTRACT.]

THE object of the paper is to state the characters of *Cœnostroma* and *Idiostroma* and in the sequel to show that the Stromatoporoids are a "comprehensive type," combining characters of Foraminifera, Amorphozoa, Anthozoa, Hydrozoa and Polyzoa. For the illustration of the paper numerous specimens and thin sections will be shown, together with many enlarged photographic views, not only of the genera above named but of several other generic modifications. But no attempt will be made here to discuss the subject exhaustively.

ON THE PHYLOGENY OF THE PLACENTAL MAMMALIA. By Prof. E. D. COPE, Philadelphia, Pa.

SECTION G.

HISTOLOGY AND MICROSCOPY.

ADDRESS

BY

SIMON HENRY GAGE, B. S.,

VICE PRESIDENT, SECTION G.

The limitations and value of histological investigation, illustrated by a consideration of the structure of a respiratory membrane in the pharynx of soft-shelled turtles (Amyda mutica and Aspidonectes spinifer).

While choosing a subject relating chiefly to microscopic structure for the address before the Section of Histology and Microscopy, I wish first to discuss briefly what constitutes a complete knowledge of structure and what are the limitations and value of this knowledge.

First and foremost, the foundation of a knowledge of structure must be laid broad and deep in a knowledge of those coarser appearances and relations that may be made out by the unaided eye. There is no magic in the microscope; it simply enables the investigator to get his eyes a little nearer the object he is studying and thus to carry his investigation a step farther. It seems as illogical and hopeless to expect to comprehend the structure of an organ or part by studying it under the microscope alone, as for a geologist to expect to understand the topography and structure of a continent by studying only the sand on its seashore.

Exactly what constitutes the knowledge of gross anatomy so strongly insisted upon, it would be out of place to discuss here; but the study of the fine or microscopic anatomy should give a knowledge of: First, the individual, structural elements and their relations to one another in the organ or tissue which they combine to form. Second, the blood supply. Third, the lymph supply. Fourth, the nerve supply and the relation of the nerves to the

structural elements. Fifth, the development or histogenesis of the structural elements and their combination to form the various tissues.

At the present time, the structure of not a single tissue or part is known in all the detail given above. From this we may gain *encouragement*, as there is opportunity for splendid achievement on every side. It also carries with it *discouragement*, for a solution of most of these problems has been found impossible by the greatest anatomists the world has known.

It is not uncommon to hear it confidently expressed that a given tissue must perform a given function on account of its structure. But as the apparently undifferentiated protoplasm of the moners, or the slightly differentiated protoplasm of the Amœba and the white blood-corpuscle, has apparently all the powers—in a limited degree to be sure—possessed by one of the higher animals, that is, it moves, feels, eats, breathes and reproduces itself; it seems to be a hopeless task to tell by structural appearances alone, what part of the protoplasm of one of the higher animals shall feel, move or breathe, and do nothing else.

Perhaps no one ever lived who was more justified in speaking dogmatically of the relations of visible structure and function than Claude Bernard; yet it was a saying of this great physiologist, that the study of mere structure gave no clew to function, except of course the grosser and merely mechanical functions.

No more striking example could be given in justification of this statement than that, before him, the most minute study of the liver and pancreas had discovered in the first merely a producer of gall and in the second only a salivary gland placed in the abdomen. And yet, the *physiologist*, Bernard, found the liver a great manufactory of sugar, and the pancreas a producer of a digestive ferment, with the powers of all the other digestive ferments combined and capable besides of emulsifying fat.

While, therefore, the most intimate knowledge of structure that it is possible to obtain at the present gives no hint whatever of the real function of a tissue or organ, this knowledge is of great value if the special function of the part is first investigated and then the structure and the relations of structure in the part determined; for undoubtedly, it is easier for the mind to grasp the details of a function if there is known the tangible structure through which the function manifests itself. Knowing with certainty the special

differentiation of structure accompanying a function it is usually safe to assume that a similar structure will possess similar properties and perform approximately the same function, whether found in the same or different animals. This structural knowledge is also of the greatest value to the morphologist, enabling him to recognize and homologize with considerable certainty the organs and tissues in different animals. And finally, it is perhaps unnecessary to state that without the knowledge of structure added to the knowledge of physiology, the splendid achievements of modern surgery would be impossible.

While, therefore, the value of our present knowledge of structure is undoubtedly very great, yet how slight is the insight gained into the relations of structure to function. Who could see in a mass of protoplasm any possibilities whatsoever if he had not first known its powers? While it is doubtless true that specialization of function is accompanied by differentiation of structure, who can state or even hint at the finer structure and structural relations which accompany extreme specialization of function? It is, for example, not very difficult to detect a nerve-fiber, but no one can from the appearance, say whether that nerve-fiber is associated with motion, sensation or the secretion of a gland: and yet between the functions of motion, secretion and sensation, there seems at present an impassable gulf.

Having thus in view the requirements for a complete elucidation of structure, and the value of that elucidation, attention is called to the structure of a respiratory organ in the pharynx of the soft shelled turtles. In the first place, however, let me briefly state the reasons for the claim that the mucous membrane of the pharynx is a respiratory organ.[1]

First, these turtles, which are in their natural condition almost constantly in water, often remain under voluntarily from two to ten consecutive hours, and while under water they fill the mouth and pharynx with water and expel it about sixteen times per minute, thus keeping the mucous membrane constantly bathed by aerated water. Chemical tests applied to the water so used by a turtle show a marked decrease in the quantity of free oxygen and a still more marked increase in the carbon dioxide; this being of course the final proof.

[1] With reference to the points here considered, see also Proc. A. A. A. S. 1883, p. 316 and this volume p. 316.

The respiratory membrane lining the pharynx is so closely beset with minute, cylindrical, often compound papillæ or filaments that it appears to the unaided eye very much like the villous coat of the small intestine of one of the higher vertebrates. This membrane commences about opposite the base of the tongue and extends to a point about opposite the middle of the third cervical vertebra, where it gradually merges into the longitudinally folded lining of the œsophagus. At this point there is a sphincter of voluntary muscle which effectually closes the œsophagus, and thus somewhat sharply limits what may be called the respiratory chamber.

The epithelium lining the mouth, pharynx and œsophagus is non-ciliated, the cells containing a nucleus and nucleolus. In the mouth it is a many-layered, stratified epithelium which gradually merges into a columnar epithelium lining the pharynx and œsophagus. The columnar epithelium is composed of a layer of elongated columnar cells, and a more or less irregular layer of smaller cells interposed between the narrow or attached ends of the columnar cells. Many of both of these varieties of cells have processes extending from their attached ends. These processes apparently combine to form, in part at least, the basement membrane which is very apparent.

In some cases there appears also a connection between the processes of the smaller intervening cells and those of the stellate cells in the reticulated tissue forming the proper mucous membrane. At the beginning of the pharynx, and also where it merges into the œsophagus, as well as in the œsophagus itself, are many beaker cells in the epithelium, but few if any of these are found in the respiratory region proper.

The blood supply is copious. There is a close network of wide capillaries with numerous, large nuclei in their walls, many of these capillaries lying next the basement membrane.

Nothing is yet known of the lymph supply.

Numerous non-medullated nerves form a plexus which appears somewhat like the plexus mesentericus of the intestine. Branches from this are sent into the papillæ and presumably terminate in the dome-shaped taste-bud, like collections of epithelia (neuro-epithelia) found there.

Such is an incomplete view of the structure of the respiratory membrane in the pharynx of the soft shelled turtles.

In conclusion it may fairly be asked: What is the special significance of the structure of this undoubted respiratory membrane? In what way does it agree with other respiratory membranes? If it be compared with the gill of a fish, the blood supply in both is ample, but the epithelium in the fish is tessellated while here it is columnar. In the ectobranchiæ of the tadpole and young newt, the structure is, in general, the same except that a columnar ciliated epithelium intervenes between the blood vessels and the water. In the entobranchiæ of the tadpole and the ectobranchiæ of Necturus a stratified pavement or transitional epithelium is present, and in the Necturus this epithelium rests directly upon the capillaries, no basement membrane being present. If a comparison be made with a respiratory membrane used in breathing air, as the lungs of an air-breathing vertebrate, the same general structure obtains. There is a pavement epithelium of a single layer, usually with a basement membrane, separating the blood vessels from the air.

The structure of each of these membranes stands out clearly from all the rest, that of the turtle resembling none of them so much as it does the villous membrane of the small intestine of a mammal. Yet each of these membranes has for its principal office the passage of free oxygen through it to the blood and of carbon dioxide from the blood to the surrounding medium.

It does not require a great anatomist to see the wide difference in structure between these various membranes and yet physiologically they are the same, and give one more demonstration of the proposition that, to be of the highest value in the advancement of knowledge, the study of structure and of function must go hand in hand.

PAPERS READ.

PHOTO-MICROGRAPHS ON GELATINE PLATES FOR LANTERN PROJECTION. By W. H. WALMSLEY, Philadelphia, Pa.

IT is generally admitted that a photograph of any object, animate or inanimate, in portraiture, landscape, architecture, or what you will, is a more literal transcript of the original, than can possibly be made by the most skilful draughtsman, since nothing is left to the imagination. If this be true with objects visible to the unaided eye, how vastly superior in accuracy is a photograph of those requiring considerable magnifying power to render their structure visible? The most perfect drawing made under the camera lucida will be found more or less diagramatic; whilst two or more drawings of the same subject, made by different artists of equal skill, will differ materially, each one pencilling what he sees; or thinks he sees. The sensitive plate, being incapable of feeling or thinking, records only the impression reflected upon it, and thus gives us an exact reproduction of the image formed by the lens.

The projecting lantern has been long used for throwing transparencies upon a suitably prepared surface, but the subjects have usually been drawings, more or less imperfect and inaccurate. The desirability of using photographs, made direct from the objects has been recognized but the cost of the necessary apparatus, together with the time, labor and skill required for its successful application, has prevented hitherto any general adoption of this most perfect method of exhibiting a microscopical specimen to a class, or audience of any kind.

The universal application and use of photography, however, brought about by the introduction of gelatine dry plates, have changed all this. The cost of the necessary apparatus has been reduced to a minimum, whilst its bulk and complexity have followed suit. The stains and disagreeable odors, attendant upon the old silver bath, and collodion process, have been consigned to oblivion. The prepared dry plates are furnished to us of uniform quality, by reliable makers, at extremely low prices, and the whole

process of making both negatives and positives may be pleasantly accomplished on a winter's evening, without even soiling one's fingers.

It is not my purpose in this paper to describe the process of making the negative. This I have already done on previous occasions, whilst other and abler pens have given us much practical information on the subject. I would merely premise that for the negative, a plate of extreme sensitiveness and fine texture, developing with sharp contrasts and great density, is required; and that development with pyro-gallic acid has in my hands given far better results than ferrous-oxalate. With such plates, powers ranging from four diameters to two thousand may be successfully employed with the light obtainable from a good coal-oil lamp, using one or two flat burners; whilst the simple and inexpensive camera shown upon the table, and which can be adapted to any microscope, is all-sufficient for the production of the most perfect negatives by any powers between the above extremes.

The gelatine plates for making positives are of quite a different character from those used for negatives, being much less sensitive to light, and requiring a development which shall produce clear glass in the high lights, transparency in the shadows, and full detail in all portions. Two distinct kinds are now made; the one with a bromide of silver base, the other with a chloride. The latter is much slower than the former, requiring many times the length of exposure, but the transparency of the shadows is so much greater, that I prefer to use them, and do not begrudge the extra time required.

Possessed of a good negative (and none other should be used, since it is impossible to make satisfactory positives from a bad one), two methods of producing the latter are open to us; by contact printing, or by the camera. The latter is undoubtedly the more perfect, and enables us to utilize a negative of any dimensions, enlarging or reducing to the proper lantern size; but it involves the cost of a copying camera and lens, and the use of daylight for producing the best effects, whilst the contact process is of the most simple description, and can be done entirely by lamplight.

For contact printing, the negative must be specially made, so that the object shown shall be within the dimensions of a lantern slide. A deep printing frame with plate glass front must be employed, on which is laid the negative, film side *up;* upon which

film side *down*, so that the two shall be in contact, is placed the slow plate which is to form the positive. Of course this must be done in the dark room by ruby light. A piece of dead-black velvet to prevent any reflection from the back of the plate must now be placed over the same, and the back of the printing frame secured in position. The exposure is made to the light of a coal-oil lamp or gas jet, at a distance of about two feet. If a *bromide* plate be employed, the length of exposure may vary from five to twenty seconds, according to density of the negative; if a *chloride* plate, however, be used the time required may be as many minutes. No rule can be given; experience alone will enable one to determine with any certainty the length of time required, and just here some failures and disappointments may be expected. It may, however, aid some and not be amiss for me to say that for negative making I have found the "Diamond" plates, by Richardson, eminently satis factory, while Carbutt's and Ripley's transparency plates leave little or nothing to be desired. They are cut from extremely thin and flat glass, so that when covered with a slip of the same thickness, and the edges neatly bound with needle paper, they present an exceedingly attractive appearance, and are very light in weight, fitting readily the carriers of any lantern in common use.

The development of the plate is of the utmost importance, since upon its success depend the beauty and perfection of the resulting transparency. The image should be sharp, clear, and transparent in the deepest shadows. Where clear glass appears, it must be absolutely so, the least smokiness or muddiness will spoil the brilliancy of the image upon the screen. The ferrous oxalate, made in the following simple manner, is entirely satisfactory when used with the Carbutt plates.

No. 1.

Saturated solution, neutral oxalate of potash.

No. 2.

Saturated solution, proto-sulphate of iron. To the latter add a few drops of a saturated solution of citric acid.

To make the developer, add one part of No. 2, to six parts of No. 1, and have ready a solution of bromide of ammonium for use in case of over-exposure.

This developer will be found to act very promptly and to bring out all details with proper density before those portions of the

plate, which have not been acted upon by light and which should be clear glass, begin to show any signs of fog. If the plate we are using be one of the bromides, it will be well to continue the development until rather more density than is desired has been obtained, as it will lose somewhat in the subsequent fixing: if, on the contrary, we are using a chloride plate, the development must be stopped as soon as requisite density is reached as it will lose nothing in fixing. The usual washing and fixing in the hypo bath followed by an alum one, and prolonged washing to remove all traces of the hyposulphite of soda, must follow as a matter of course. Should the image flash up too suddenly from over-exposure, add a few drops of the bromide solution, as a restrainer, to prevent flatness and want of contrast in the image.

If the negative image be of larger dimensions than the lantern plate, and it be desired to place the whole thereof upon the latter, it will be necessary to employ some kind of a copying camera. One specially constructed for this purpose, with a double shifting front, capable of carrying any sized plate, will of course be found the best. In the absence of such we may successfully use the same camera with which the negative was made, by removing the cone front and putting the negative in its place, which can readily be done by any one possessing a little patience and ingenuity. Then a board, carrying a rectilinear lens of moderate focal length, must be inserted in the central division of the bellows, and the front elevated toward the sky. An image of the exact size required may now be thrown upon the focussing screen by withdrawing the front section of the bellows carrying the lens, to the proper distance, where it must be clamped, and the focussing effected by the back bellows, which carry the ground glass screen. The plate holder containing one of the slow lantern plates is now to be substituted for the ground glass, and an exposure of five to twenty seconds made, governed by the density of the negative. The subsequent operations of development and fixing are precisely the same as those given for contact printing.

Should the resultant positive be lacking in density, or of a slaty hue, and without crispness, it may frequently be greatly improved by the following method. After thorough washing to remove all traces of hypo, place it in a bath composed of: bi-chloride of mercury, 96 grains; bromide of potassium, 90 grains; distilled water, 12 ounces. This bath, it may be observed, should be re-

turned to a well stopped bottle for future use, as it will retain its qualities for a very long period.

Its effect upon the gelatine film of the plate will be to bleach the same, but care must be exercised not to carry the bleaching too far, lest over-density be the final result. Removed from this bath and well washed, it must be plunged into another consisting of a ten per cent solution of sulphite of soda, until the desired tone is reached. Almost any gradation of color from a light yellow brown to black, may be thus obtained, varied by the length of time immersion in the soda bath is continued. Final washing and drying must follow, as in the original development.

When dry, the film is to be protected from injury by covering it with a thin plate of glass, of the same dimensions as the slide, with a mat of paper, cut out in suitable shape, placed between the two, and the edges bound around with a strip of needle paper.

PHOTO-MICROGRAPHY WITH HIGH POWERS. By Prof. T. J. BURRILL, University of Illinois, Champaign, Ill.

[ABSTRACT.]

DR. H. J. Detmers of Champaign, Ill., succeeded in February, 1885, in making good photographs of *Amphipleura pellucida* mounted in balsam, by use of a common coal-oil lamp and the ordinary microscope accessories. Oblique illumination was obtained first by using an Abbe condenser and afterward, with still better results, a Wenham half button. The microscope was simply turned to the horizontal position, the end of tube with eye-piece inserted into a short camera and the adjustments made directly by the hand while the operator stood in position for viewing the image upon the focussing plate.

By using diatoms mounted in a more highly refractive medium, magnificent results were obtained.

At my suggestion, Mr. S. W. Stratton designed and constructed a new heliostat of simple mechanism which answers the purpose required in photo-micrography as well as the more elaborate and more expensive instruments and is far more readily managed. For those who need to have the sun's rays constantly thrown in any given direction for one day only (without resetting) the apparatus is all that may be desired.

A NEW, CHEAP, USEFUL AND QUICKLY CONSTRUCTED ADJUSTABLE MICROTOME. By Dr. CHARLES PORTER HART, Wyoming, Ohio.[1]

[ABSTRACT.]

THIS instrument is nothing more nor less than a Bausch and Lomb microscope stand, converted into a microtome, by the following changes:—Having removed the sub-stage, the slide-carrier clips, the objective adapter, and the draw-tubes, a suitable razor blade is permanently fixed to the slide-carrier, so as to have a corresponding universal lever movement parallel to the glass stage. The imbedded substance is then carried down the main tube of the instrument (which is placed in a horizontal position) until it presses gently against the microtome knife, where it is fixed in position within the tube by means of the main draw-tube, the diaphragm of which, either directly, or by means of a small wooden cylinder, is brought in contact with the distal extremity of the substance to be divided, and this acts as a plug or follower to retain it in position within the tube. Then, having moistened the knife, and, if necessary, the substance to be operated on also, the slide-carrier, and with it the microtome knife, is made to pass through a sort of revolving cutting motion, by which the sections are made. These sections may be made of any degree of delicacy by means of the micrometer screw attached to the instrument.

OPTICAL ARRANGEMENTS FOR PHOTO-MICROGRAPHY, AND REMARKS ON MAGNIFICATION. By ROMYN HITCHCOCK, Smithsonian Institution, Washington, D. C.

[ABSTRACT.[2]]

THERE are two methods of obtaining amplification in photographing microscopic objects; one is by regulating the distance of the sensitive plate, the other is by the interposition of an eye-piece.

The conditions in photography are somewhat different from those of ordinary observation, wherein the defects of the ocular are not noticeable. The eye fails to discover a curvature of the image

[1] Now Professor of Neurology in Hahnemann Medical College, San Francisco, Cal.
[2] Printed in full in the American Microscopical Journal, Sept., 1885.

which is very evident when the latter is spread over a flat focussing screen six or eight inches square. In photography much depends upon whether the operator uses large or small plates; for, with a small plate, giving a field of three or four inches, very high magnification can be satisfactorily attained by the aid of an ocular. For ordinary purposes such plates are quite large enough, but when we come to large sizes, such as eight by ten-inch plates, the eye-piece will not give sharp definition all over the field.

The eye-piece enables one to obtain increased magnification with short camera-bellows, and we have seen small photographs of difficult subjects taken with the eye-piece which leave nothing to be desired. Nevertheless, for the more difficult objects, and whenever finest details are to be photographed, we would not advise its use. By far the better plan is to use a long camera-box, and get amplification by increase of distance. In this way very good results can be obtained, but it must be observed that the objective requires to be specially corrected for the distance of the plate, and this is not only inconvenient, but in many cases quite impracticable. Thus, in using an objective of the oil-immersion form without any collar adjustment, one can only focus the image on the plate by causing the objective to approach nearer to the object than where it is used in ordinary observation.

In working with objectives corrected with the utmost care for a definite length of tube, it is obvious that any changes in the course of the rays passing through the objective will introduce aberrations which will impair the definition. If we focus upon an object with the ocular, then remove the ocular and receive the image upon a focussing screen several feet away, the objective must be moved nearer to the object in order to give a sharp image on the screen. Shortening the working focal length in this way obviously interferes with the normal course of the rays through the lens, and it is therefore not possible to obtain such a perfect image in this way as may be seen with the ocular. It will readily be seen that the only way to secure the best definition is to focus the objective with the ocular, for then we know the corrections are properly adjusted, and then make the image sharp on the distant screen without the eye-piece by means of a supplementary lens. Mr. Zeiss attempted to do this by providing suitable correcting lenses to be screwed into the back of the objective, which were calculated to correct the aberrations when the screen is at stated distances away. A better

plan, however, was employed by Dr. Woodward, who fully understood the problem and solved it in a satisfactory manner. He made use of an amplifier by Tolles, which he found to be most satisfactory of all at the time. The amplifier was placed in a draw-tube, so that it could be moved out or in as required. He found that for any given position of the screen there was a corresponding position for the amplifier at which the image was as sharp and perfect as when observed with an ocular the objective meanwhile remaining unmoved. Herein is the secret of Dr. Woodward's unexcelled work in photographing the most difficult test-objects. He used no small plates, but the images of *A. pellucida* were ten inches in length, clear and sharp throughout. It is safe to assert that such pictures cannot be taken with an ocular, or even without the correcting lens properly applied. These facts are either not generally known, or they are sadly neglected by those who have most need to apply them; for in these days of photographing the most difficult of all objects, the various forms of bacteria, the utmost sharpness of definition is required if the results are to possess permanent value.

We now come to another question of importance in connection with this subject, viz., how much shall we magnify with each objective? We already know that there is a limit, clearly determined by calculation for each objective, dependent upon its numerical aperture, beyond which no further amplification will bring out additional details. Beyond that limit increase of magnification only enlarges the details then visible. Experience clearly shows, also, that as we increase amplification beyond a certain point, with every objective, we lose in sharpness of definition. This should be borne in mind in photographing with the microscope. The negative should be taken with only such magnification as gives perfectly sharp definition. By far the greater part of the general photographic work of microscopists is done with powers not greater than 250 diameters, and rarely indeed is 400-500 diameters required.

Summing up this matter, we are personally inclined to favor the use of large plates, 8 by 10 inches for example, in photomicrography, using the lens with an amplifier instead of an eye-piece, for the reason that large pictures, highly magnified, can thus be obtained of exquisite definition. These will bear further enlarging with the solar camera. There remains, however, the consideration of expense, and the inconvenience of using such a large

apparatus under ordinary circumstances. It is unquestionably more convenient, in most cases, to use smaller plates, and to work with an eye-piece. Still better, to use an amplifier in place of the ocular, for then it is possible to attach the amplifier to the camera in such a position that when the object is focussed with the eye-piece, it is also in focus on the ground glass of the camera when the latter is attached. With such an arrangement a quarter-plate camera can be used with perfect satisfaction, giving negatives equal to any that can be made.

The same cannot be said when the ocular is used, although there is no doubt that thoroughly satisfactory results can be obtained with the ocular on small plates, as already explained.

SECTION H.

ANTHROPOLOGY.

ADDRESS

BY

WILLIAM H. DALL.

VICE PRESIDENT, SECTION H, ANTHROPOLOGY.

THE NATIVE TRIBES OF ALASKA.

LADIES AND GENTLEMEN:—It is now sixteen years since I read my first ethnological paper before this association, at the Salem meeting in 1869. That paper sketched the distribution of the native tribes of Alaska and adjacent territory, together with some of their most salient characteristics, and formed a summary of what advances had been made in the knowledge of such matters in that region since 1855, when Holmberg published his ethnographic sketch of the people of Russian America.

On this occasion I propose to return to the same subject, to indicate the principal investigations which have added to our knowledge since 1869 and to briefly sum up its present state, adding a few remarks on the directions in which future study may be most profitably employed. That the present is a particularly suitable time to call attention to the subject I am led to believe for several reasons.

At the time when my paper of 1869 was read, anthropological study in Alaska had passed through several phases and was entering upon another. The first period in which material for such study had been collected began with the expedition of Bering and Chirikoff and lasted during the remainder of the eighteenth century. It was characterized by maritime discovery and the preliminary mapping of the coast by the early navigators, often men of keen observation, whose accounts of the inhabitants of the coasts they explored are still of great value, and for the most part quite reliable within obvious limits. To this period belong the names of Cook, Vancouver, Bodega, Maurelle, Gray, Meares, Dixon, Portlock, Vasilieff, Krenitzin and Levasheff, and a host of lesser

Russian navigators whose records have been preserved for us by the laudable efforts of Coxe.

The second period may be said to have begun with the establishment, as a legalized monopoly, of the Russian American Company and the consequent circumnavigations of the globe by Russian naval vessels, which brought mails and accessories of civilization to the rude and hardy fur-hunters of the northwest coast. These began with the voyage of Krusenstern in the *Nadezhda* and the work begun by him was admirably carried on by his successors; Lisianski, Kotzebue, Golofnin, Vasilieff, Wrangell, Lütke, Tebienkoff and others. Many of these expeditions were accompanied by men of science, either as surgeons or as special investigators, whose names to the biologist and anthropologist are as household words. Such were Langsdorff, Chamisso, Merck, Eschscholtz, Choris, Kittlitz, Postells and Mertens.

Other nations though naturally behind the Russians were not absent from the field. The voyage of Beechey and later of Sir Edward Belcher; Dease and Simpson, and other officers and servants of the Hudson Bay company, combining exploration and commerce or barter; the United States exploring expedition under Wilkes, and the North Pacific exploring expedition under Ringgold and Rodgers; all added materially to our knowledge. A single group of expeditions sent by Great Britain, in addition to the above mentioned, were also not fruitless, though, considering the opportunities offered, the results were extremely meagre. I refer to the Franklin relief expeditions on the ships *Herald* and *Plover*, *Enterprise* and *Investigator*.

The names of Collinson, McClure, Kellett, Moore and Maguire, are familiar to all interested in arctic geography; and Hooper, J. Simpson and Seemann, who accompanied one or the other of these parties, have left their imprint on the history of anthropological research. During this period also the noble and devoted Veniaminoff began his missionary labors in Alaska simultaneously with which he accumulated data for memoirs on the natural history of man which will always remain standards of reference.

With the return to Europe of officers who had served their time in the colonies and whose scientific tastes had led them into studies of the people over whom they had ruled, material accumulated, until in 1855, the work of the anthropologist in Alaska and adjacent regions was summed up by Holmberg in the paper I have al-

ready alluded to. Much that is to be found in it is fundamental and must form a part of any systematic arrangement of the people of Northwest America. It was practically copied by Wehrman in Tikhmenieff's History of the Russian American Company. But a Russian officer by the name of Zagoskin had been ordered to the Yukon region in 1843. According to the reports of those who were with him, this man was extremely lazy and inefficient. He relied in great part on the ill-interpreted information, often partly fabulous, obtained from the natives. From these he cooked up accounts of journeys never made and maps of rivers never visited, with lists of tribes who never existed as such but were perhaps the inhabitants of some hamlet of three huts in the distant interior. He did not intentionally misrepresent the people or the country and there is much that is true and useful in his report. However he desired to magnify his own labors and researches and in the way indicated succeeded in incorporating much that was erroneous which affected the work of Holmberg and others who took the report, as it stood, as a foundation for their studies.

In 1839 Elia Wossnessenski reached the northwest coast, as an agent of the Imperial Academy of Sciences at St. Petersburg, to make collections in Alaska. Aided by the Russian American Company, a magnificent ethnological collection was made in duplicate, of which one series went to Russia; the other was retained in the Colonial Museum at Sitka; the remnants of this have fortunately found a resting place in the Peabody Museum at Cambridge, after some curious vicissitudes. This was the first systematic attempt to represent the arts and industries of the Alaskan peoples in any collection. It was, of course, defective in regard to the interior tribes and those of the Arctic coast, but, for the tribes accessible to the Russians, it was originally very complete and, except for destructible objects made of skin and other animal products, still remains so. The progress of investigation in the direction of anthropology received a check by the breaking out of the Anglo-Russian war of 1854–57, and came to a standstill with the failure of the Russian American Company to secure a renewal of their charter in 1862. After that expenses were curtailed, scientific explorations by the Russians ceased, and the civilized population of Alaska carried on their fur-trading and other business in a mood of expectancy.

In 1861, Robert Kennicott, of Chicago, had been carried by the

fervor of his inborn love of science far into the inhospitable north. Aided by the Hudson Bay Company, under the auspices of the Smithsonian Institution, he penetrated the territory, then known as that of the Hudson Bay Company, to its extremest trading post, and in that year descended the Yukon from Fort Yukon nearly to the limits of Russian exploration, coming from the opposite direction.

After his return the projectors of the international telegraph, believing from repeated failures that no long ocean cable would be of permanent use, called upon him for information in regard to the possibility of a line, with a very short cable across Bering Strait, via Arctic America and Siberia. After some negotiations it was determined to explore for such a line, and Kennicott, in consideration of the opportunities for the scientific exploration of an almost unknown interior region, agreed in 1864 to direct the work in what was then Russian America. With him went a small band of young men actuated by the same spirit, or kindled by the inspiration of their leader, of whom Rothrock, Bannister, Elliott and the speaker still survive.

This expedition marked the dawn of a third era for the investigation of that region. The expedition, considered in its commercial aspect, was a failure, but the explorations it set on foot bore permanent fruit. The parties were withdrawn, in 1867, after three years of labor. The final success of the Atlantic cable rendered the project of a land-line through an arctic territory no longer advisable. The speaker continued his work there for another year on his own responsibility and at his own expense, feeling that unless this was done the previous work would be only too fragmentary to cover the plan of investigation he had laid out. Kennicott, overcome by his labors, had passed over to the majority. The maps, notes, records and papers of the expedition, in the haste to reduce expenses and close an unprofitable account, were scattered without publication and little profit was reaped by the public, from most of its operations. The work of the scientific corps, however, was more fortunate, but instead of appearing as it should in a general report devoted to all branches of the subject, which would always have remained a standard of reference, circumstances compelled its publication in single papers in a variety of journals, or in works intended rather for the public than for the student.

The close of our work was soon followed by the purchase of the territory from Russia by the United States. For nearly sixteen years the immense region, thus acquired, hung in the political firmament, like Mahommed's coffin, neither a foreign country nor yet on the solid ground of a legally organized territory of the Union.

During this period, recently brought to a close by the establishment of a legal government, exploration continued more or less active. The agents of the general government visited many parts of the territory. The emissaries of the Smithsonian Institution, inspired by Baird and Henry, spared no endeavors to gather and record facts bearing on all branches of science.

The signal service established meteorological stations. The Army sent officers to determine the northeastern boundary on the Yukon. The Navy visited numerous ports and brought back precious documents and collections. The Revenue Marine contributed, through the researches of its officers, an immense mass of material and observation. The Coast Survey utilized to the utmost its opportunities and with satisfactory success.

Other agents of the United States, either as revenue or census officers, contributed their quota. Something was gained through the Arctic expedition of the unfortunate De Long and the others sent to rescue or discover the fate of his party.

The International Polar Station at Point Barrow, though planted upon the most inhospitable soil, has borne excellent fruit, some of which is yet to be made publicly accessible.

Even foreign lands have contributed to the work. The wonderful voyage of the Vega, with her wintering on the adjacent coast of Siberia, and subsequent visit to American shores, is known to every one. Pinart's philological tours, the admirable work done by the brothers Krause, and the indefatigable journeys of Capt. Jacobsen, cannot be overlooked.

In all this activity there was of course much inferior work done by persons unqualified either by training or habits of accurate observation. Numerous petty agents of the Treasury have reported from time to time, in documents of fortunately limited circulation, some of which reveal to the student official Bunsbyism of the purest breed.

The same observation has been repeatedly made, each time announced, in good faith, as new. Explorations over routes

trodden by hundreds of predecessors have formed the subject of long disquisitions, and rivers to be found on every respectable map of the last thirty years have been reported as new discoveries and furnished with a whole set of new names. These, however, are the faults of youthful inexperience and enthusiasm, and few, even of these publications, but have contained some new and welcome facts. They would hardly be worth the notice of the speaker were it not for the fact that they form pitfalls for the inexperienced student who should not, because it is new to him, suppose that the anthropology of Alaska is still a virgin field. Its literature in fact is enormous and rapidly increasing.

The era which, with the just organized government of the region, is now fairly begun, differs in several particulars from the one just described. Tourists have found that the magnificent scenery, and cool even summer weather of the southeast Alaskan region, may be reached and enjoyed with little trouble and expense.

The lavish purchases of foreign collectors have exhausted, in many localities, the whole supply of genuine old carvings and stone implements. It was announced, not long since, that a dealer at Juneau was intending to import a good stone-cutter for the winter, to supply his shop with stone implements for the summer trade of 1885. Wooden carvings and similar "curios" are now regularly made for sale to tourists, and often show singular modifications from the aboriginal types.

The first "inscribed tablet" was forged at Sitka in 1868. It was a Phœnician one. We may look for a large crop of them in the future should the market prove satisfactory.

Nearly every traveller, in little known parts of the world, brings home some one story with which, half in jest, he gratifies the natural demand for the marvellous, on the part of his acquaintances. These stories may be found in the usual proportion in most accounts of Alaskan travel, and have occasionally been transplanted to scientific works of great respectability.

To the young anthropologist we would say therefore, that when a particularly astonishing "fact" is presented for his consideration, it is an excellent occasion to fall back on the reserve of scepticism which every scientific man is supposed to carry in a small bag somewhere near his heart.

The missionary who has begun his benevolent, and we hope, ul-

timately fruitful work among the wild tribes of Alaska, frequently has not the remotest notion of the wonderfully complicated and exact system of ethical philosophy which has been elaborated by his brown brother, and the rendering thereof in his letters to the missionary paper is apt to be more graphic than accurate. I have seen a story in a work of the highest reputation to the effect that a favorite dish of the inhabitants of Kadiak is composed of a mixture of bears' dung. When we consider that the nearest approach to an oath in the native dialect is to tell an adversary to "eat dung," the value of such a statement is evident. It has probably arisen from the habit of the Eskimo of making a sort of salad of the willow bud croppings which, at certain seasons, are found in the anterior pouch or crop of the reindeer, where they are as clean and nearly as dry, as if in a basket. They are eaten for medicinal reasons by the Innuit. In the story a deer has become a bear, and the willow buds dung, but how, it is difficult to imagine. But enough on this topic; the Indian is a man like ourselves with much the same tendencies, and, except where his peculiar ethics bind him, a parallel to his love, hate, appetites and aspirations may be seen not fundamentally modified, in those of our own children.

My classification of 1869[1], somewhat enlarged, was republished in "Alaska and its resources"[2] and in 1877, an expanded and improved revision, with a good deal of added information and synonymy, appeared in the first volume of Contributions to North American Ethnology.[3] It is to the latter that I refer as a standard of comparisons in the ensuing summary of progress.

Innuit.

Western Eskimo. It was well understood by me in 1870, and has since been fully confirmed, that most of the Arctic Innuit are not separated into tribes in the same sense that the Indians of the United States, east of the Mississippi, were at the time of their discovery, nor even to the same extent as those Innuit, south

[1] On the distribution of the native tribes of Alaska and the adjacent territory. Proc. Am. Assoc. Adv. Sci., eighteenth (Salem) meeting, pp. 262–273, 8°. Cambridge. J. Lovering, 1870.

[2] Alaska and its resources, by W. H. Dall, xii, 628 pp. 8°. Boston, Lee & Shepard, 1870.

[3] On the distribution and nomenclature of the native tribes of Alaska and the adjacent territory. Contr. to Am. Ethn. Vol. 1, pp. 7–40, 4°. Washington, Government printing office, 1877. The manuscript was actually prepared for the printer in 1875.

from Kotzebue Sound on the northwest coast. Terms were used to indicate the groups of Innuit geographically separated from each other by a stretch of unoccupied coast and, for convenience, these terms were referred to as tribes. This is practically their own fashion. The people are all known as Innuit, those from a certain quarter have a special name, and those from each village in that district or each river, have a still more special name. But there are no chiefs, no tribal relations in the strict sense, and the only distinction used among the people referred to is based on their locality of origin; they freely migrate from village to village or district and are not regarded as foreigners, though the obligation of free hospitality is not felt to be binding in regard to strangers from a distance, long domiciled in another than their native village. We have no new information from the Kopagmut (*l. c.*, p.10) nor from the people of the Colville river, except a few notes derived from the Point Barrow people by Prof. John Murdoch during his sojourn at Cape Smythe, as a member of Lieut. Ray's party, on duty at the International Polar Station known as Uglā-āmi. In the course of his admirable ethnological investigations he found that the Point Barrow people have the habit of using the plural rather than the collective form of the designation for a particular people, and call those of the Mackenzie river district by the term Kŭpūng'-mi-ūn (Kopagmūt) and those of the Colville Kŭng-mŭd'-ling (Kŭng-māligmūt). The Point Barrow people call themselves and are called by the other Innuit, Nū-wūng-mi-ūn (Nū-wūk-mūt, people of the point). They call the people of the Nunatok river Nūn-ā-tăn'-mi-ūn (Nūnātăgmūt) and call the Indians of the interior (Kŭt-chin) It-kŭd'-ling, which is probably (like In-kā-lit of the more southern Innuit) a term of reproach or contempt.

For the people of Point Barrow, Mr. Murdoch and the other members of Lieut. Ray's party obtained rich ethnological data which are in process of publication.

Some interesting facts have also been gathered by Capt. Hooper of the U. S. Revenue cutter Corwin during several visits to Point Barrow. As a whole, we shall soon be in possession of very full information in regard to this isolated band.

Of the Nūnātăkmūt we have nothing since 1877, and of the Kū-ăgmūt (Kowăgmūt, *op. cit.* p. 12) only a few facts collected by Lieut. J. C. Cantwell of the U. S. Revenue Marine, during his

exploration of the river in 1884. He reports that the local name of the river is Kū-ăk not Kowak, as generally adopted on the charts. From Lieutenant Stoney who followed him, and who has since returned to the region to carry on a more extensive exploration, a large addition to our knowledge of these Innuit may be expected in the near future.

Of the Innuit from Kotzebue Sound around to Norton Sound little bearing on their classification or language has been gathered since 1877. The observations of Nordenskiöld and the Vega party at Port Clarence in 1879, and of the speaker in charge of the U. S. Coast Survey party in 1880, at Port Clarence and the Diomedes, as well as Kotzebue Sound and the Asiatic coast near by; of Hooper in the Corwin, 1878–80; of the Jeannette expedition in 1879, have added numerous facts, but little bearing on their distribution or classification, which was not already known.

Yūit; Asiatic Eskimo. The most interesting people of the region adjacent to Bering strait are the Asiatic dwellers on the coast, part of whom belong to the Korăk race and part to the Orarian group of people. In no other ethnic group of the region has research been better rewarded since 1877. We have the admirable observations of the Vega party, the arduous explorations of Arthur and Aurel Krause, and some observations of my own, all of which taken together have done much to clear up one of the most knotty ethnological puzzles of the northern regions. I give the results in brief as my time is not sufficient to go into details. The Asiatic coast presents us with the Tsaŭ-yū (plural Tsau-yūat) or Tsau-chū, a people of Korak extraction, commonly known as sedentary Chukchi, who have lost their reindeer and settled upon the coast, adopting from their Innuit neighbors much of their peculiar culture, but not their language. These people bear about the same relation to the wandering or reindeer Chukchi that the fishing or farming Lapps do to the Mountain Lapps of Lapland. Among them, with their little villages sometimes side by side, are to be found the Asiatic Innuit, who call themselves Yūit (by local corruption of the race name) and who present essentially the features of the Western Innuit of America, with some local differences. They migrate with the seasons from Cape Oliutorsk to East Cape; their most northern permanent village as far as known is at the latter point.[4] The

[4]The Census Map is erroneous in regard to their distribution southwestward.

Tsau-chū extend along the northern coast of Siberia much farther north and west. The two races are friendly, there is some intermingling of blood by marriage and a jargon containing words of both dialects is used in communications between them. In my opinion, however, it is very necessary to keep in view, that the culture of the Tsau-chū, so far as it differs from that of the wandering Chukchi, is distinctly a derivative from that older culture of the Innuit race, though the arctic people of both hemispheres and all races have much in common, due to their environment. The word Chukchi has been so misused that it is almost meaningless, but, in the strict and accurate meaning of the word, there are no Chukchi on the American coast, as has been asserted. That error arose from the confusion between the Innuit and Yuit on the one hand and the Tsau-chū on the other.

Southwestern Innuit. Of the Innuit people on the American coast at Norton Sound and southward to the Peninsula of Aliaska, not much additional information has been made public since 1877 bearing on their classification. That in the Report on Aliaska comprised in the publications of the U. S. Census of 1880 is retrograde in many particulars rather than an advance, being the work of a person unqualified for the task. Magnificent collections bearing on the culture of these people have been made by Turner, E. W. Nelson, W. J. Fisher, C. H. Mackay and others, and have been received by the U. S. National Museum. But the unfortunate ill health of Mr. Nelson and other circumstances have delayed the publication of his rich and valuable observations. A good deal has also been done in the way of collections on the island of St. Lawrence by Hooper and Nelson and in the Aleutian Islands by Turner, Dall and others.

With regard to the tribal limits of the Western Innuit, geographically considered, they are very mutable and especially in recent years are constantly changing in small details. This arises from the fact that the geographical group which we have called a tribe among the Innuit, and for which in some cases they have a special designation, is not a political organization headed by a chief or chiefs, but simply a geographical aggregation of people who have by possession obtained certain *de facto* rights of hunting, fishing etc., over a certain area. The jealousy of adjacent groups keeps the imaginary boundary line pretty well defined through fear of reprisals should it be violated. When the whites come in with

trade and established posts all over the region, they also use their power to put down any conflicts, which are always injurious to trade. The boundaries now violable with impunity fall into oblivion and the more energetic hunters and trappers go where they choose. In this manner the geographical group names I have described are ceasing to have any serious significance and every new ethnographical visitor will find himself unable to make the ancient boundaries correspond to the distribution of the moment. Nevertheless, in a general way the old maps such as that of 1877 still indicate the focus of the former group or tribe and doubtless will long continue to do so. The Innuit tribes on the Kuskokwim have been found by Nelson to extend farther up the river than was supposed in 1877, reaching nearly or quite to Kolmakoff trading post. The advance up the Yukon shown on the census map is recent, if authentic. The St. Lawrence Island people are more nearly related to the Innuit of the American coast than to those of Asia, though their commerce is with the latter and with their Korak neighbors. As regards the Innuit of the region between the Koyukuk River and the Selawik River, the miscegenation indicated by the census map has no foundation in fact. The error doubtless arose from the permission accorded by the Innuit to special parties of Tinneh to come into and through the territory of the former, for purposes of trade.[5] The north shore of the peninsula east of Port Möller is represented by the census map as occupied by the Aleuts or Unŭngŭn. The region is really not inhabited, except for a few temporary hunting stations, except by typical Innuit. Notwithstanding these and many other errors in this compilation, it is probably correct in extending the area of Tinneh about Selawik Lake, which is a useful addition to our knowledge. In 1880 while visiting Cook's Inlet I was enabled to determine the essential identity of the native Innuit of Kenai with those of Prince William Sound though among them were many Koniag'mūt brought there for purposes of trade in hunting the sea-otter.

With regard to the Aleuts, the degree of civilization to which they have attained is very promising. The people are not scattered over the archipelago except in their hunting parties. In the western Aleutian Islands the only permanent villages are at Attu and Atka Islands. The division into groups is rather a matter

[5] The first white men to visit this region were J. S. Dyer and Richard Cotter in 1866. Zagoskin's alleged journey was fabulous and concocted by him in the Nulato trading post. Jacobsen and Woolfe have since made the trip and perhaps others.

of tradition than of actuality; practically they are as much one people as those of two adjacent English counties.

The easternmost of the Innuit people are the Chūgăchîgmūt of Prince William Sound. At their eastern limit there has long been a confusion, which I supposed I had cleared up in 1874 but which has only been finally regulated by information received from the brothers Krause and obtained by myself in 1880. The census agent who visited them in 1881 was frightened by some boisterous demonstrations and departed in the night in a small canoe; abandoning his equipage, after a stay of some forty-eight hours. Consequently very little information was obtained by him and that of an uncertain character.

Three stocks approximate to each other at this point, the Chūgăchîgmūt Innuit, the Tinneh of Copper River, and the Chilkaht tribe of Tlinkit. The latter have a precarious traffic, coastwise; a few canoes annually reaching the Chilkaht village (sometimes called Chilkhaak) at Controller Bay by the dangerous voyage from Yakutat. But another path lies open to them, at least at times. One of Dr. Krause's Indian guides informed him that he had descended the Altsekh river (a branch of the Atna or Copper river) which heads near the Chilkat River at the head of Lynn Canal, to a village of his own tribe at its mouth on the seacoast. Of the visits of the Ah-tenā tribe of the Tinneh I have had personal observation and that the Chūgăchîgmūt pass by them to the Kayak Island in summer all authorities are agreed. This information explains the confusion of previous evidence and shows why the vocabularies have sometimes afforded testimony in favor of one view and sometimes of another. A jargon is probably in use in communications between the Tlinkit and the Innuit. That any ethnic intermingling of blood has taken place I regard as too improbable to be worth consideration, having had personal evidence of the fear and hate existing between the two peoples. There is some distrust between the Tinneh and the Innuit, as elsewhere, but the bold and aggressive Tlinkit have committed so many outrages upon the timid and peaceable Chūgăchîgmūt, that the feeling there is of a much more bitter character.

I have elsewhere stated my reasons for believing that the Innuit formerly extended much farther to the south and east. Nothing has since been discovered which materially affects the grounds of this belief of mine, and the subject is an interesting one for future investigation.

TLINKIT OR KALOSHIANS, AND HAIDA.

The investigations for the census in 1880, in southeastern Alaska, were committed to Mr. Miletich of Sitka, who deputized the Rev. S. Hall Young and some of the other missionaries to obtain the number and distribution of the native inhabitants.[6]

This work done by men of education and intelligence, whose interests would all be in the direction of accuracy, has given us a valuable and the first reliable indication of the geographical distribution of the smaller groups of the Tlinkit within our territory. Whether these groups are entitled to rank as tribes, or whether they do not rather correspond to clans or to purely geographical divisions, subordinate to those indicated in 1877 I am as yet unable to determine. Doubtless the work which Dr. Krause is understood to have in hand will give us praiseworthy and final data upon the subject. The most interesting result of the census work was the extension of the range of the Haida to the northern end of Prince of Wales Island. In this we have a new fact properly authenticated, and for which we are grateful.

Several books have been published by the missionaries on their life in Alaska, most of which do not contain much of value to the ethnologist; with greater knowledge and experience we may hope for something more satisfying.

The most important contributions to our knowledge of the people and culture of this part of Alaska since 1875, is due to the labors of Drs. Arthur and Aurel Krause which are too well known for me to need to specify them in detail.

Mr. J. G. Swan, of Washington Territory, has made extensive and valuable collections for the National Museum both from southeastern Alaska and the region south and east of it in British Columbia.

Dr. Friedrich Müller has devoted much study to the Tlinkit language and has published observations on their verb. Dr. A. Pfizmaier has pursued investigations in the same direction; both of these rest their work chiefly on the classical study of the Kaloshians by Veniaminoff. But it is impracticable in an address of this sort to attempt too close an investigation or record of details.

[6] This has not been stated by the compiler of the final census report, who, nevertheless, if I am correctly informed, was entirely dependent upon these sources for all that is new and valuable in regard to southeastern Alaska, embodied in the said report.

Tinneh or Athabaskans

To the knowledge of these people in Alaska little or nothing has been added of late.

The Kŭn-ŭn-ah′ or Stick Indians, who inhabit the Lewis branch of the Yukon heading near the Lynn Canal, have been visited by numerous parties of whites, and lately by Lieutenant Schwatka, who has given some interesting details as to the life and condition of these Indians, and especially of those lands on the Iyon (Hai-an, Ayan, etc., whence Hai-ankutchin or Han-kutchin, the latter probably a corruption of the former) river and the upper part of the Yukon, about which so little has been known.

I was able to definitely determine, during my visit to Cook's Inlet in 1880, the proper name of the Tinneh tribe which live on its shores; the K'nai-ăkhotana (Knaitse or Kenaitze of the Russian, Tinnats by corruption; Tehaninkutchin of the Yukon tribes north of them) whose range was determined by Petroff to include and surround the great Iliamna Lake.

There has been for two seasons a military party endeavoring to ascend the Atna or Copper river from the sea. Doubtless the report on the country and people which we may expect from them on their return will be replete with greatly needed ethnological as well as geographical information.

Adjacent tribes.

In closing my sketch of progress in anthropological knowledge in the far northwest, I cannot omit (though somewhat beyond our boundaries) calling your attention to the valuable work of Dr. Geo. M. Dawson of the Canadian Geological Survey. He has published an admirable monograph on the Haida of Queen Charlotte Islands, and in connection with the veteran Dr. W. F. Tolmie, a series of comparative vocabularies of the British Columbian tribes, illustrated by a map of their distribution. This fills a gap in ethnographic maps which has long reproachfully appealed to the eye of the student, and for the first time renders possible a general discussion of Northwest American tribes.

We should not forget, however, that our knowledge is still for the most part approximate, especially in regard to what are called tribes, and that a really comprehensive treatment of this branch of the subject must be reserved for more precise data still to be collected.

Well knowing the defects of much that has been done by myself and others, and that numerous corrections are to be anticipated from impartial criticism in the future, I have in the preceding sketch avoided, as much as might be, destructive criticism, however tempting the opportunity. To this rule I have been forced to make an exception in regard to an imposing official document included in Vol. VIII of the recent monographs of the census of 1880. I felt this to be due to students, who might well be excused for supposing such a work to contain the last word on the subject of which it treats, especially as it does contain a large amount of compiled material from respectable sources.

An outline of the tribes as at present recognized is appended; when the limits of 1877 still hold good, only that date follows the name. Synonymy is only attempted when necessary to clear up some misunderstanding. The term tribe, as will be understood from the foregoing, is used only in a tentative manner.

ORARIANS.

Innuit stock.

(Northwestern Innuit.)	
Kopăg'-mūt, 1877.[7]	Estimated population. ——
Kāng-mālig'mūt, 1877.[8]	3100?
Nūwūk-mūt, 1877.[9]	
Nūnătŏg'mūt, 1877.[10]	
Kū-ăg'mūt, 1877.[11]	
(Asiatic Innuit.)	——
Yuit.[12]	
(Island Innuit.)	
Imăh-kli-mūt.[13]	——
Ing-ŭh-kli-mūt.[14]	40?
Shi-wo-kŭg-mūt.[15]	150?

[7] Erroneously located on census map. Population for Alaska only.

[8] Erroneously omitted from census map.

[9] This term applies only to the Point Barrow people, but they are not differentiated from others as far southeast as Point Hope. See *op. cit.* 1877, p. 11.

[10] Range very erroneously extended without data, on the census map. It would appear from the reports of Cantwell and Stoney that on the Kū-ăk or Kowak river is the most numerous band of the area embraced under the name on that map.

[11] Kowăg'mut, 1877. These practically include Selăwigmūt.

[12] Chūklūk-mūt, 1877. Southern range incorrectly indicated on census map. Nogwŭh-mūt at East Cape.

[13] Big Diomede Island people.

[14] Little Diomede Island people.

[15] St. Lawrence Island people, Kikh-tŏg-a-mūt of 1877.

(Western Innuit.)

Kăviăg'-mūt, 1877.[16]	14,500?
Măh'-le-mūt, 1877.[17]	
Un-ālig'-mūt, 1877.	
Ikŏg'-mūt, 1877.[18]	
Măg'emūt.[19]	
Kai-ā lig-mūt.	
Kŭskwŏg'mūt.[20]	
Nūshāgag'-mūt,[21] 1877.	
Oglemūt.[22]	
Kăniăg'mūt.[23]	
Chū-gach'igmūt.[24]	

(Aleutians)

Unŭngŭn, 1877.	2,200?

INDIANS.

Tinneh or Athabaskan stock.

(Western Tinneh.)[25]

Kai'-yŭh-kho-tā'nā, 1877.	2,000?
Ko-yū'-kŭkh-o-tā'-nā, 1877.	
Un'-ā kho-tā'-nā, 1877.	

(Kutchin tribes).

Ten'an'-kŭt-chin', 1877.	700?
Tennŭth'-kŭt-chin', 1877.	Extinct.
Tăt-sâh'-kŭt-chin' 1877.	Extinct.

[16] King-i'-gă-mūt of the census map refers only to the people of the village at Cape Prince of Wales. See *op. cit.* p. 16.

[17] Range erroneously extended north of Selawik Lake on the census map.

[18] E kŏg-mūt of 1877, but the present spelling is preferable.

[19] The Nunivak people, at least on the north coast, call themselves Măgemūt. The Kaialigmūt, according to Nelson, are interposed on the mainland between the northern Măgemūt and the Kŭskwogmūt.

[20] The Kŭskwŏgmūt, according to Nelson, extend inland to Kolmakoff redoubt on the Kuskokwim river.

[21] This name covers the Ching-ig'-mūt and Togiăg'-mūt of the census map. There seems to be little differentiation between these bands.

[22] The Agle-mūt of some authorities (*op. cit.* 1877, p. 19). According to Petroff, the Tinneh are interposed between them and the south shore of Iliamna Lake. They extend southeastward to the mountains of the peninsula and range westward at times to Port Möller.

[23] With the boundaries of 1877, except the end of Kenai peninsula.

[24] From the western extreme of Kenai peninsula to the mouth of the Copper or Atna river and Kaye or Kayak Island.

[25] In so far as the classification of the Western Tinneh of the Census Report differs from that of 1877, it is a falling back on the earlier state of confusion which prevailed before the collection of data on which the work of 1877 was based. The word Kai-chana used in that report is not an Indian word at all but a colonial Russian expression used of any interior Tinneh with whom they were little familiar.

Kŭt-chā'-kŭt-chin', 1877.	
Natsit'-kŭt-chin, 1877.	
Vŭntā'-kŭt-chin', 1877.	
Hai-ăn'-kŭt-chin'.[26]	
Tŭt-chohn'-kŭt-chin (?) 1877.	
(Eastern Tinneh.)	614
K'nai'-ā-kho-tana.[27]	250?
Ah-tenā', 1877.	——
(Nehaunees.)[28]	——
Abbā-to-tenāh, 1877.	——
Acheto-tinneh, 1877.	——
Khŭn-ŭn-āh'.[29]	——
(Carriers.)[30]	
"Takŭlli."	——
T'silkotinneh.	
Tlinkit or Kaloshian stock.	
Chilkaht-kwan.[31]	1314
Yăk-ū-tăt', 1877.	500?
Sit-ka-kwan, 1877.	
Stakhin-kwan, 1877.[32]	4949
Skŭt-kwan (?) Dawson, 1884.	
Haida stock.	788
Haida.[33]	
Tsimpsi-an' stock.	
Tsimp-si-an'.	——

This terminates the list of tribes in or immediately adjacent to Alaskan territory. For further material those interested are referred to Tolmie and Dawson.

[26]Han'-kŭtchin of 1877. Their range should be extended to Fort Selkirk on the Yukon and the lower part of the Iyon (or Ai-an) river (see Coast survey map of Alaska, 1884) though their settled villages are on the lower part of this range as indicated in 1877. The Tŭt-chone' kŭt-chin of 1877 move in a similar manner, up stream for the hunting and down stream for the fishing season. It is probable some of the little known tribes grouped in 1877, under the name of Nehaunees, will require to be consolidated as perhaps different names for the same tribe.

[27]Verified personally in 1880. Tehānin' kŭtchin of 1877.

[28]The tribes under this head are only provisionally classified as in 1877.

[29]Stick Indians of the traders. Inhabit the basin of the Lewis River and trade with the Chilkahtkwan. They are Nehaunees E. and F. of 1877.

[30]The tribes of British Columbia are quoted from Dawson and Tolmie (*op. cit.* 1884.)

[31]To their distribution in 1877 must be added their colony at the mouth of the At-na River. See preceding pages of this address. Chilkaak and Chilkaat of Census Map.

[32]The local septs or subdivisions are named in the report of 1877 (p. 38) and probably more fully indicated as to boundaries on the Census Map.

[33]The corrected area in Alaska occupied by these people has been referred to and is indicated on the Census map. These people evidently form a separate family, allied to the Tlinkit; Kai-gah-ni of 1877 is the name of a local sept. For others see Dawson.

PAPERS READ.

Permanence of early Iroquois clans and sachemships.

By Rev. W. M. Beauchamp, Baldwinsville, N. Y.

Besides the direct advantages of the League, many have thought that the Iroquois tribal system evinces wonderful foresight, and have readily believed that the names and apportionment of the sachems, as well as the principal ceremonies, continue as they were at first. This is to suppose that a few savages, hundreds of years ago, conceived and established an intricate political and social system, with wise checks and powers, needing little improvement and adapted to every emergency. Wise regulations there certainly were, but their antiquity and origin may well be questioned.

Impressed with the practical nature of much that is real, we may become enthusiastic, and find more foresight and permanence than actually exist. This appears in accounts of the totems and tribes and the limitation and perpetuation of the sachem's office. The tribal division is indeed curious and interesting, but too much may be claimed for it. The subject has an historic interest, but its main importance is in showing that the originator of the Iroquois League was not a striking anomaly in savage life.

The Iroquois confederacy seems originally to have been a loose union of the Five Nations, gradually becoming firmer. When Champlain went against the Onondagas in 1615, there was no fear that the neighboring Oneidas would come to their aid. When the French colonists set out from Quebec, in 1656, the Mohawks maltreated their Onondaga escort, and the dread of a war with that nation alone moderated their violence. In return, the Onondagas plundered a party of Mohawks farther up the river. The same year the Onondagas convoked the allied nations, "to reconcile the Mohawks with the Senecas, who were on the point of commencing a war." The nature of the union was so little conspicuous, that the Dutch long spoke of them only as the Mohawks and Senecas, considering the Oneidas as the first division of the latter.

The powers of the Grand Council at first were very limited. "Every year," said a French missionary, "they hold a general assembly at Onondaga, where all the deputies of the other nations meet to make their complaints, and receive the necessary satisfactions, by mutual presents, by which they best keep on good terms with each other." Every nation made war or peace for itself. The Grand Council simply removed grievances, though sometimes, and gradually more and more, treating of general dangers and advantages.

Aside from this, were Iroquois institutions strictly permanent? No one who studies the history and customs of that interesting people will assert this except in a general way. Remembering many influences within and without, we are prepared for great changes. Wampum appears in all their councils in historic times, and yet it is certain there was an earlier period, when they knew nothing of this. It is an absurdity to date any existing belt, as early as the formation of the League. The pipe of peace is popularly supposed to have figured in all their councils, as smoking certainly did; but in the early part of the last century some western Indians explained its meaning to the Iroquois, as though it were new to them. Their burial customs changed greatly, and their present feasts and dances are not always those of the olden time. The great white dog feast, in its leading features, seems to have been known only to the Senecas one hundred years ago. The Jesuits first, and Con-ya-tau-you afterwards, twice revolutionized their religious system. Their mode of building degenerated; the early and late stockades were not alike, and the use of guns changed warfare. They no longer wore defensive armor, or depended on bows and arrows. Clothing, cooking and agriculture were not as of old.

And these things happened naturally, through intercourse with the French and English and war with distant nations. They saw many tribes and customs, and adopted other Indians by hundreds. Large villages of the captive Hurons were placed among the Cayugas and Senecas, and multitudes of Hurons, Eries and Neutrals were received by the others. One object of war was to gain strength by adopting captives. To say that all this produced no change in laws and customs is to fly in the face of all experience. The wonder is that aught of Iroquois character remained.

The Totemic Bond, as it is sometimes called, has naturally

awakened admiration by its results. In a broad way, it may be said, that in each confederate nation were certain tribes or clans, who were brothers wherever they met. The Mohawk Bear was received and aided by the Cayuga Bear; the Oneida Turtle by the Seneca Turtle. In each nation, also, some tribes of differing totems were brothers, somewhat as in the nations, the Mohawks, Onondagas and Senecas were Elder Brothers, and the others Younger. These things caused a bond which was not merely national, and seems a wise plan, if at first it was a plan at all. But tribes and totems varied in the different nations, and what becomes of original design, when a tribe in one finds no corresponding tribe in another?

Were these clans the same at all times? In his "League of the Iroquois," Mr. L. H. Morgan names eight tribes for each nation, in a general way, divided into two brotherhoods. The Bear, Wolf, Turtle and Bear form one; the Deer, Snipe, Heron and Hawk are the other. Some writers make one class superior to the other, and its members alone eligible to office. Mr. Morgan makes no such distinction, and indeed assigns the sachemships among the Onondagas and Senecas to seven tribes existing, as he states, when the League was formed. In his list, the fourteen Onondaga sachems of the Grand Council were of the Wolf, Beaver, Bear, Turtle, Snipe and Deer tribes, while the eight Seneca sachems were of the Wolf, Bear, Turtle, Snipe and Hawk; and in these clans, he says, they were perpetually hereditary. His exact division gives the Mohawks and Oneidas three tribes each; the Onondagas, Cayugas and Senecas, eight tribes; and the Tuscaroras seven. In a later work he assigns eight to the latter. But this does away with any true plan, for wise design would not have left five tribes without members in two nations; indeed, some were confined to one.

Mr. Morgan may be right when he says that the Totemic Bond "furnishes the chief reason of the tenacity with which the fragments of the League still cling together," though what bond exists between the Seneca Deer and any tribe of the Mohawks does not appear; but he is too enthusiastic when he adds, "The history of the Ho-de-no-sau-nee exhibits the wisdom of these organic provisions; for, during the long period through which the League subsisted, they never fell into anarchy, nor even approximated to dissolution from internal disorders." If they did not, we have already seen that it was because the Grand Council settled disputes,

not because of the mutual affection of the separate clans. To my mind these were accidents, not wise organic provisions. Two hundred years ago the Canadian Mohawks refused to fight the eastern Iroquois, but their scruples vanished when they were led against the Senecas. Nationality was stronger than clanship.

Indian statements and traditions are conflicting, and often worth very little, but if it is true that, "tradition declares that the Bear and Deer were the original tribes, and that the rest were subdivisions," this implies natural change. When Mr. Morgan first wrote, the clans were more in some nations than he seems to have known, and have been even greater in times past. He did not then mention the Eel tribe, now the largest clan of the New York Onondagas. In his "House Life," he gives quite a different list. That of the Tuscaroras is but little like one furnished me by an intelligent Indian, born and bred among them. The Eel is mentioned among the Onondagas, Cayugas and Tuscaroras. The Ball is substituted for the Hawk among the Onondagas, doing away with both the Heron and Eagle. If such changes have occurred in the tribes, is it probable that the sachemships have in no way changed? And then it may be asked, are these lists trustworthy?

In writing on Iroquois customs in 1771, Sir William Johnson said, "Every nation is divided into a certain number of tribes, of which some have three, as the Turtle, Bear, and Wolf, to which others add the Snake, Deer, etc. Each of these tribes forms a little community within the nation, and as the nation has its peculiar symbol, so each tribe has the peculiar badge whence it is denominated, and a sachem of each tribe being a necessary party to a fair conveyance, such sachem affixes the mark of the tribe thereto." He seems to say that sachems were chosen from *all* the tribes, as is the case now, but the principal ones may have been intended. At a council held at Albany, in 1700, composed of a multitude of sachems, a business conference was held with some from each nation, apart from the rest. They brought in others, saying that "all business of moment was to be transacted by the Three Ensigns that the five nations consisted of, to wit, the Bear, the Wolf and the Turtle; therefore one from each of these tribes or ensigns in each nation was to be present." Yet in Morgan's list no Cayuga sachem of the Wolf tribe appears. So, also, the Seneca sachem Kanarighton, who signed the important deed of 1726, affixed the totem of the Heron tribe, which this list does

not credit with a sachemship; and the same totem appears in another treaty, as the mark of a Seneca sachem. When the French made a treaty with the Onondagas, in 1665, the six ambassadors affixed "the distinctive mark of their tribes,—The Bear, the Wolf and the Tortoise."

In the New York Documentary History (vol. 1, p. 3,) under date of 1666, a French writer describes nine Iroquois tribes, with illustrations. The Tortoise, Wolf, Bear and Beaver, are the first division, called four tribes; the Deer, Potato, Great Plover, Little Plover and Eagle, are the second, called five tribes. The sign of the tribe was painted in the gable end of the cabin in black or red; and a warrior tattooed himself with the signs of his nation and clan, and lastly with his own mark.

Changes came, and a Frenchman, adopted by the Senecas, gave another enumeration seventy years later. "The five villages, which belong to the same tribe, have for their arms in common, the Plover, to which I belong; the Bear, the Tortoise, the Eel, the Deer, the Beaver, the Potato, the Falcon, the Lark and the Partridge." These are ten in number and as some appear in no other list, they may be due to foreign elements among the Senecas, not yet thoroughly assimilated. It would seem probable that the Potato clan had such an origin. The Wolf is left out, apparently by mistake, and one of the Plovers also. The Eel, Lark and Partridge are introduced.

In Clark's History of Onondaga, eight clans are mentioned, the four superior tribes being as usual, but he adds that "the inferior clans are the Deer, Eagle, Heron and Eel, from which civil chiefs may not be elected." He probably calls the Snipe the Heron, as the latter is not recognized among the Onondagas. Mrs. E. A. Smith, also going to native sources, gives the division of the Onondagas, for the games, as uniting on one side the Bear, Deer, Eel and Hawk, against the Wolf, Beaver, Snipe and Turtle.

I am told by them, however, that there are no Bears left among the New York Onondagas, which may prove a mistake, that there is no Hawk or Eagle clan, the Eel having been found to be its equivalent, and that the Turtle is divided into large and small, as among the Tuscaroras. The Eels among that nation are all Onondagas. It will be remembered that Mr. Morgan mentioned the Ball clan. There is no such tribe, but in the story of Hiawatha this was one name of the Onondagas. This great man gave names

as he pleased. Leaving the Mohawks he came to part of the Oneidas, gathered about a great stone, and he said, "These are the People of the Stone." He came to another party resting under a large tree, and the Great Tree became a second name. The first Onondagas he saw were on a high hill, and the name has come down to us; but the next party were playing ball, and they had a name from this which very few have known.

At no time does there seem to have been more than the Wolf, Bear and Turtle tribes among the Mohawks, and these once dwelt in separate villages. An Oneida chief tells me that there are not more than this among the Oneidas now, and these three clans may have been the original Iroquois stock, to which others were soon added by adoption. The Tuscaroras have their clans emblazoned on a banner, which bears a seven-headed snake and six blue stars on a red union.

One striking feature of this Iroquois system was that members of a clan must marry into another, the children being of the mother's tribe. Maternal authority is so marked that when an Onondaga child is taught the commandment on honoring parents, it invariably places the mother before the father. Yet the Oneida whom I have mentioned, and whose father was an Onondaga of the Snipe tribe, calls himself a Snipe, and is so considered. Some assert that originally the superior and inferior clans could not marry into their own class, with the awkward consequence that the three tribes of the Mohawks and Oneidas could not marry at all.

The system of Iroquois sachemships has been represented as inflexible and commemorative in names and numbers. Doubtless there has been an attempt at both, and yet without full success. Under the circumstances changes were inevitable. Mr. Morgan's scheme, obtained at a Grand Council, makes fifty sachems the rulers of the League, all permanently assigned to certain nations and clans. Yet, according to the original compact, he says, two of the first Mohawk sachems had no successors, reducing their representation to seven, and making the whole number forty-eight. It would seem quite as likely, however, that when this scheme took form the Mohawks had already become weakened by intercourse with the whites, and having less sachems, made their weakness appear magnanimity.

If the scheme holds good three tribes of the Mohawks had at first nine, and then seven sachems; three of the Oneidas nine; five of the

Onondagas fourteen; six of the Cayugas ten; five of the Senecas eight; leaving the Tuscaroras unrepresented.

Were these offices thus unchangeable in numbers and apportionment? It might be unfair to do more than refer to the present condition of the Onondagas, so much are they changed, and so little do they know of their own laws. Each clan has at least one principal chief (the Snipes have two) and he is assisted by a war chief, who stands behind him to deliver messages, and execute his commands. The principal chiefs may sit in the Grand Council, though delegates are commonly sent.

It will be better to turn to history. In the first treaty made between the Five Nations and the English, in 1664, three sachems appeared for the Mohawks, and four for the four other nations, collectively called Senecas. The names given, and the titles affixed, have no resemblance to the modern list of fifty sachems.

At the treaty with the French, two years later, ten Seneca and ten Oneida ambassadors affixed their names. Necessarily, these were all sachems. At a council in Albany, June 2, 1691, the names of six Oneida sachems present were recorded, of eleven Onondagas, four Cayugas, and eleven Senecas. In September, of the same year, six Seneca sachems, came from another castle, making seventeen in a council far from their homes, while the modern list allows but eight for the full number. At a later council, in August, 1700, eleven Mohawk sachems attended; six Oneidas, eleven Onondagas, eleven Cayugas and eleven Seneca sachems, besides many warriors. This gives sachems in excess of the list to three nations; but this is not all. When Lord Bellomont asked these fifty sachems whether they would name the sachems to select a place for a fort, they answered, "that they could be better named at Onondaga, where there were a great many." At the same time a sachem from each of the four western nations was in Canada.

Major Dirck Wessell's journal, at the council at Onondaga in 1693, tells of its large size. He had advised the Mohawks not to attend the council, so that but four nations were there. The whole house met, and "there being eighty sachems present, Kajarsanhondare made answer." This can only be understood of the Grand Council as constituted two hundred years ago.

In 1694, the Onondagas said they had sent nine sachems to Canada, with nine belts, and were uneasy at having trusted almost

half the sachems of their nation with the French. At Colonel Schuyler's visit, in April, 1700, twelve Onondaga sachems are mentioned by name, and their speaker Aradji said, "most of the sachems of this castle are abroad."

At a conference in July, 1701, nine Mohawk sachems were present, and twelve Onondagas, while some sachems of the latter were in Canada. The following year, while eleven Onondaga sachems were at Albany, nearly as many were with the French Governor.

The modern list gives the Senecas but eight sachems. Their castles were so far away that some sent no delegates to Albany for a long time. In May, 1720, Myndert Schuyler held a conference in the Seneca country. When he reached their principal castle, some of the sachems were abroad, and these and those at Onaghee were sent for. Four came from Onaghee, but wished to consult again with the sachems remaining at their own castle. They restored a former sachem, as desired by the commissioners. The full number certainly could not have been less than twenty, as but two castles are mentioned out of several.

King Hendrick's example might be cited, he having been deposed, and some years later restored; a thing not easily done if the number were absolutely fixed, for there seems to have been no vacant place for him to fill. All these things seem conclusive that the number of sachems was variable, larger than has been supposed, and on a different apportionment.

Were the transmitted or conferred titles permanent? Several writers claim that they are the same that they were in the beginning, as some may well be. It is well known that titles of some antiquity are conferred on new sachems yet, so that they thenceforth have an additional name. In very few cases are they known to us by their new titles. But it is certain that the titles have not always been the same. In June, 1701, the Onondagas and Cayugas both acquainted the Council with the deaths of chief captains and appointed others with the same names, but these names do not appear in the modern list. The same was the case when the chief sachem of Cayuga introduced two new Seneca sachems to Sir William Johnson, in 1750, and announced their new titles. They are not on the list of the supposed original sachems.

On the choice of sachems Sir William Johnson remarked (in 1771) that they "are usually chosen in a public assembly of the

chiefs and warriors whenever a vacancy happens by death or otherwise. They are generally chosen for their sense and bravery, from among the oldest warriors, and approved of by all the tribe; on which they are saluted sachems. There are, however, several exceptions, for some families have a kind of inheritance in the office, and are called to this station in infancy." He clearly distinguishes between sachems and chiefs.

Essentially, Mr. Morgan takes much the same view of changes, when, admitting the necessity of raising up chiefs without limitation of number, he says that now "they have raised themselves to an equality in many respects, with the sachems themselves." He says also, of the Tuscaroras, that "they were never allowed to have a sachem who could sit as an equal in the council of sachems." But he adds, "They also enjoyed a nominal equality in the councils of the League, and their sachems were raised up with the same ceremonies." This seems a distinction without a difference. As early as 1722, the Tuscaroras became parties to a treaty establishing peace, and regulating boundaries, and they always appear afterwards.

As the line of descent is through the mother, it is often said that the son of a sachem or chief cannot be a chief, but Kakedoa, the son of Bunt, chief sachem of Onondaga, was introduced to Colonel Guy Johnson as a sachem, one of the great men that ruled over them. At the same time eleven recently appointed Onondaga sachems were present. Other like historical instances occur. In a case under my own eye, a father, son and grandson, have successively been prominent chiefs of the Onondagas, and the last two, at least, members of the Grand Council.

Mr. Morgan says on this point, "Logan was one of the ten Cayuga sachems, but which of the ten names or sachemships he held is not at present ascertained. His father Shikellimus, or Shikalimo, who is usually mentioned as a Cayuga sachem, was but a chief." This seems mere assertion, and may or may not be correct. As Shikellimus was Executive Deputy of the Iroquois Grand Council at Shamokin, and as such ruled the Delawares, it seems reasonable that he was of the highest rank.

My own experience is that the Iroquois themselves are not very clear as to their own usages, and their ideas of antiquity are little to be trusted. The facts stated plainly show that the number and names of the sachems have not been the same at all times, that

hereditary rights must be understood in a general way, and that the varying division into clans was rather accidental than the result of any far-seeing wisdom.

There remains but one question more. Have the original ceremonies for raising sachems come down to us? Only in a general way, if at all. A tradition has been related to me that at one time they had met to raise sachems, but through recent losses, there was no one who could go through the ceremonies. While perplexed over this an old woman said she knew them all, and instructed those present in the whole. At a later day some of these seem to have been placed in a more permanent form, and yet it is not well agreed among themselves now what is right. In the main they depend on oral tradition, and those who differ in usage criticise the rest. While they were engaged in wars, meeting with losses, adopting captives in a wholesale way, depending altogether on unwritten tradition, and yet influenced by the adoption of French and English usages, it is easily seen to what a strain their ceremonies were subjected. Wampum enters largely into these, and no wampum is found on prehistoric Iroquois sites. It belongs to a later age, and yet something might have supplied its place.

But we find evident changes: French and English governors condoled the dead, and had something to do with the appointment and institution of sachems. When Hendrick the Mohawk, and another sachem were killed, both were condoled, and a new sachem was raised in the place of the latter. Sir William Johnson's presence was requested, but as he was detained, he sent the necessary belts, and desired the Mohawk sachems to act for him. He spoke of their customs, and the rules laid down by their wise ancestors. The Oneidas and Tuscaroras alone condoled with the Mohawks at this time, and complained that the Onondagas, Cayugas and Senecas had passed by the door without attending. The same month he condoled the dead generally, and replaced them with prisoners, the account concluding with these words: "Thus ended the ceremony necessary on these occasions, agreeable to their customs." Is this the present ceremony?

When, a little later, the Canajoharie Mohawks presented one of their most capable men to succeed Tarrachioris, of the Turtle tribe, as sachem, Sir William Johnson said, "I now, in the presence of your whole castle, invest him with all the powers of a sachem, and put on him those necessary marks of distinction,

which I wish him long life to wear." This, however, was aside from their own ceremonies of condolence, but was accepted as an institution. Among themselves, however, condolence and raising sachems were not necessarily united. They mourned Hendrick, but deferred the election of his successor. When new sachems were instituted Sir William Johnson put their names on record, and the discovery of this list would prove a matter of great interest. The account of the condoling ceremony in which he shared at Onondaga, at the death of Kaghswoughtiooni, or Red Head, chief sachem of that nation, is quite full, and may be compared with other like occasions. Three days before, Sir William and the sachems of every nation had prepared proper speeches and belts for the ceremony, at his camp at Oneida. Marching thence, three Cayuga sachems met him a mile east of Onondaga Castle, "to settle the formalities of the condolence, agreeable to the ancient custom of the Six Nations." This took two hours, and then he "marched on at the head of the sachems, singing the condoling song, which contains the names, laws and customs of their renowned ancestors, and praying to God that their deceased brother might be blessed with happiness in his other state. This ceremony was performed by Abraham, the chief Mohawk sachem," and two Oneidas. Properly, now, this would not belong to the Mohawks, but sachems are sometimes "borrowed" for such occasions. When they came in sight of the castle a line of silent sachems and warriors sat in a half circle across the road. Here the condoling song was sung by the visiting sachems. The Onondagas then rose and shook hands, and welcomed them to their town. Sir William marched at the head of the warriors, the sachems falling behind and continuing their song. Within the gate salutes were fired, and "the sachems proceeded to a green arbor adjoining to the deceased sachem's house, prepared on purpose." When they were seated, Sir William was sent for and addressed them.

The next day the full council met, with the baronet at its head, for the grand ceremony, which was performed by Old Abraham the Mohawk. First a large belt covered the grave; a second belt comforted the relatives; a third admonished the surviving councillors to maintain the covenant with the English; a fourth dispelled the clouds of day, and a fifth those of night, when Grand Councils were held. "These compliments of condolence were enforced by eleven belts and three strings of wampum, and a scalp

of the enemy to replace the deceased, and with a glass of rum round to wash down all sorrow and grief, the whole ceremony of condolence ended." This was the Iroquois condolence for a great sachem in 1756. Was it thus ordered by the first sachems? and is it thus performed now?

In 1768 the younger branches of the League, the Oneidas, Tuscaroras and Cayugas, went through the whole ceremony of condolence with the Elder Brothers, on the death of a Mohawk sachem, and the brotherhoods were then clearly distinguished. Several times we have accounts of institutions in full council, in the simplest possible manner. The announcement of the choice and title, the giving of a little wampum to each nation, ended the matter.

It was really the ceremony of condolence, and not a feast of the dead like that of the Hurons, which Father Pierron witnessed among the Mohawks in 1670. "The assembly," he says, "was composed of Onondagas, some Oneidas, and the most eminent of the Mohawks. These were separated from the others according to custom." The Onondaga spoke first, and the Mohawks, in reply, "discoursed of their fables and superstitions," and then sang. The ceremony took place at some distance from the village, and lasted five hours, but the missionary did not wait for its conclusion by the Mohawks. Except in a very general way it seems little like the ceremonies of later times.

Giving the Iroquois due honor for much practical wisdom, we need not ascribe all to the founders of the League. Change is natural, and there may be progress among savage as well as civilized men. Yet in dealing with a people who know so little of themselves, we may hesitate about positive statements, so very easy is it to be in error even when the authority seems good. The stories differ, and we may take our choice; not being over credulous, but measuring what they say now by what those who have known them best in the past have recorded of them.

INDIAN PERSONAL NAMES. By Rev. J. OWEN DORSEY, Bureau of Ethnology, Washington, D. C.

"WHAT'S in a name?" has been asked by many a one besides the author of the query. Among the Jews and other nations of antiquity, every personal name had a known meaning. At the present day, names are given without any consideration for their literal meanings, although in some cases so-called family names are held in honor on account of their association with the past.

All Indian personal names have meanings, many of which have been preserved to this day; and it has been the good fortune of the writer to record names of Omahas, Ponkas, Kansas, Osages, Kwapas, Iowas, Otos, Missouris, and Winnebagos. In some of these tribes, over two hundred personal names have been found. The writer has long desired to prepare a comparative list of the names of all the tribes which have been mentioned. But he has been obliged to content himself with collating Omaha and Ponka names, and afterward, Iowa, Oto, and Missouri names.

In the study of the gentes or clans of any tribe, it is necessary to examine personal names, as in many instances they contain references to past or present tribal customs, the mythical origin of the gentes, etc., *e. g.*, the Omaha Te-pa-i-ta-zhi people, who *keep* the sacred buffalo skull, cannot *touch* it, though the skull plays a very important part in the installation of Omaha (and Ponka) chiefs. The question arises, what gens can touch the skull? We find another gens called Te-sin-de, Buffalo Tail, composed of those who cannot touch a buffalo tail, etc. We infer that these taboos are correlatives, and that those who cannot touch the buffalo tail can touch the buffalo skull! This may be incorrect, but in the Omaha Hañga gens, those who *can* eat the buffalo *tongues*, *cannot* eat the meat on the *ribs*, and *vice versa*. If the inference is correct, the Buffalo Tail men are probably those from whom one is chosen to paint the privileged decoration (Hanga ki'a^{n}ze) on the skull, and thrust the wild sage into the vomer, prior to the installation of chiefs. In support of this, we find in the Buffalo Tail gens the name Wild Sage, now borne by the head man of a subgens, who is called the keeper of a sacred pipe! The name is a ni-ki-e, or sacred name, and is in a buffalo gens, so the coincidence can hardly be accidental. Mr. F. LaFlesche, a fellow of this Association, and a member of the Omaha tribe, maintains that the Buffalo Tail people cannot touch a buffalo head. Granting that

he was correctly informed, it is still very probable that they played an important part in the installation of chiefs, collecting the wild sage for that occasion. In further support of this view, we find that the Ponkas have a buffalo gens called Ma-ka^n, Medicine, which seems to point to the wild sage, and these Maka^n people, as well as the Omaha Tesinde, cannot touch a buffalo tail!

Personal names may be classed as follows, beginning with male names:—

1. Cardinal birth-names. Among the Omahas and cognate tribes, these are four for each sex, and are used by the kindred in addressing a boy (or girl). First son Iñ-gdha$^{n'}$. Second son, Iñ-ké. Third son, Ka'-ga. Fourth son, Ka-gé. First daughter, Wi-na$^{n'}$ (or, Winau'). Second, Si-gé. Third, A-si'. Fourth, Wi-hé. These eight names are in the Ponka and Omaha dialect. The first son is always called Iñgdha^n, though there may be daughters older than he; and the first daughter is always Wina^n; but the Dakotas do not call the first son Cha-ské ("first child, if a boy") if there have been daughters born before him; nor do they address the first daughter as Wi-no'-na (see Wina^n above) unless she is the firstborn child.

II. Nikie[1] names. These refer to a mythical ancestor, to some part of his body, to some of his acts, or to some ancient rite which he may have established. These nikie names are of several kinds.

(A) Seven Ordinal birth-names for each sex. In the Elk gens of the Omahas, for instance, are these boys' names: Young Elk, Big Elk, Four Horns (of an elk four years old), Dark Horns (of a fullgrown elk), Big Elk with Branching horns, Soft Horns (of a young elk, at their first appearance), and Branching Horns (of a two year old elk.

(B) Other nikie names, not birth-names, but peculiar to a single gens, as, Elk, Standing Elk, White Elk, etc.

(C) Nikie names common to two or more gentes. In explanation of this, it seems probable that if the name did not belong originally to a single gens, all the gentes now using it must have had a common mythical ancestor, or else mythical ancestors of the same genus or species. The study of the Kansas tribe reveals what they call "Zha-zhe ki-k'ŭ'-be," *i. e.*, certain gentes exchange personal names. These may coincide with the "Wa-yŭ^n min-dŭ^n" or "Those who sing the sacred songs together" (Phratries).

[1] Pronounced "Né-ke-ay."

III. Names which may have been nikie names, but which seem to have lost their original meanings. These fall into four subdivisions:— (A) Names related to those in a cognate tribe, as the Omaha Ki-ba-khdha-hi, and the Kansas Ki-ba-khla-hü; or the Ponka A-zhañ-gi-dhe, and the Kansas Wa-zhañ-gü-ye. (B) Names borrowed from another tribe of the same group or stock, as, Ahi-ska, White Wings, an Omaha name, from the Kansas Ahü ska. (C) Ancient names which have been in use for many generations till the true meanings have been lost, as, Mi-ke-ni-dhe. (D) Names common to many tribes, as, Ga-hi-ge (Omaha and Ponka), Ga-hi^{n}-ge (Kansas), or Ka-hi-ke (Osage, Iowa, etc.).

IV. Names that are classed as dream names (uha^{n}bdhe) or mysterious names(u-khu-be-a-ta-dhi-sha^{n}), names of guardian spirits of animals, as, Te-bi-'a, Frog. These are called Totem names by some writers.

V. War or Bravery names, as War Captain, and Brave.

VI. Names founded on the man's past history, including names of ridicule, many of which are vulgar, *e. g.*, U-ha^{n}zhiñ-ga (Small Boiler, or, Boiled a little, a name for a stingy man who would not boil much food for a feast which he gave.

VII. Modern names. Names common to several tribes, divided thus:—

(A) Names common to the gentes of a single tribe, or which may be used by any member of the tribe. Some of these are borrowed from the white people, as, U-ha-hi (Ohio), and U-ma^{n}-ha^{n} ta^{n}-wa^{n}-gdha^{n} (Omaha city). Others are of native origin, as, Ni-bdha-ska (Nebraska), and A-gdhi^{n}-du ba (Fourteen).

(B) Names common to several cognate tribes, as, Dha-'e-ga^{n} (Poor man).

(C) Names used by tribes of different stocks, as, A-sha-wa-ge, Spotted Horse, a Pawnee name given to a Ponka chief; Du-dha-he, Good, a Pawnee name in Omaha notation; Wa-khwa-ta^{n}-dhiñ-ge, Not poor, an Oto name in Omaha notation; and Wa-khpe-sha, Red Leaf, a Dakota name adopted without change. Grizzly-bear names are not nikie names among the Omahas, Ponkas, Iowas, Otos, and Missouris.

The following law about nikie names has been observed by the Omahas. There must never be more than one person in a gens having any special (nikie) name. For instance, when in any household a child is called Young Black-bear, that name cannot be given

to any other new-born member of that gens; but when the holder of the name changes it for another, or dies, another infant can receive the name in question. As this is one of the seven Ordinal birth-names of the Omaha Black-bear people, it suggests a reason for having extra nikie names in the gens. These extra names may have been birth names, resorted to whenever the original seven were already appropriated. This rule applies, in some degree, to girls' names. If parents know that one girl in the gens has a certain name, they cannot give that name to their daughter. But should they select that name when ignorant that another girl already had it, they must distinguish between the two girls by adding to their common name those of their respective fathers.

Names of females may be classed as follows: —

I. Four cardinal birth-names, Wina^n, etc., common to all gentes.

II. Ordinal birth-names, seven for each gens. (Sometimes subgentes, as among the Dha-ta-da gens, have their special lists of birth-names.)

III. Names derived from the names of gentes, as, Dhi-ghi-da Female, of the Ponka Dhighida gens; Kansas Female, of the Omaha Kansas gens; and Pigeon Female, of the Oto Pigeon gens.

IV. Names from vegetation, as, Much-more-corn-comes-up-than-was-planted Female, Dry-beans-falling-of-their-own-accord Female, Sweet-smelling Cedar Female, Thin-corn Female, Two-Corn-blades Female, Corn-stalk-joints Female, and Fallen-Corn-blossom Female.

V. Wind names, as Wind Female, and South-wind Female.

VI. Water names, as, Female Who-plays-on-the-water, Female Who-walks-on-the-water, Female Going-beneath-the-water, Water Human-being Female.

VII. Thunder and Thunder-bird names. She-who-strews-the-ground-with-a-long-line-of-dark-bodies. Roaring. Comes Roaring. Distant-white Thunder Female. Real Thunder-Eagle Female. Thunder-Pigeon Female. Thunder Has-come Female.[2]

VIII. Names of animate objects, parts of such objects, their actions, etc. Female Elk. Iron-eye Female (*i. e.*, the elk). Distant-white Buffalo Female.

IX. Names of the moon and its phases. Moon moving during the day. Turning Moon Female (*sic*). Looking at the Moon.

[2] There seems to be a class of composite mythical animals in the philosophy of Siouan (or Dakotan) tribes as, Thunder-Eagle, Thunder-Hawk, Thunder-pigeon, Moon-hawk, Human-male-Eagle.

Moon that is travelling. Moon-Hawk Female. Moon has returned visibly. Moon that is flying. Foremost Moon. Moon Horn Female. Moon that is low. Moon moving on high. Moon that they fear to see. First Moon. Mysterious Moon. Black Moon. Visible Moon. Visible one Moving. Visible Moons scattered (Paraselenae?). She who is ever coming back visibly. She who walks visibly.

X. Mythical names, which will be described hereafter.

XI. Unclassified names, among which are Female difficult to be seen, Female who is coming out, Female that shoots the day, Female flying with them, Female with fire in her mouth, Female who makes the earth live (or shake), Female who has come from on high, One post Female, Four posts Female, Female who has returned from Bear land. The last may be compared with a Navajo myth, told by Dr. Washington Matthews in his paper entitled, "Mythological Dry-painting among the Navajos," read before the Anthropological and Philosophical Societies, Washington, D.C.

Many Omahas and Ponkas can tell the tribe and gens to which a name belongs as soon as they hear it. Thus: Te'-dhi-ti^{n}, Buffalo Rib, is of the Omaha Black-bear sub-gens; but Te-dhi'-ti^{n}, of the Ponka Hisada gens, part of which are Black-bear people.

Of Wing names, Black Wings, Hard Wings, Short Wings and Large Wings are Oto. White Wings is found in the Ponka Hisada (a bird gens), and Omaha Dhatada gentes. Parts of the Dhatada are small bird and eagle sub-gentes. Red Wings (of a blackbird) is found in the Kansas Bird, and Omaha Dhatada gentes. Black Wolf, and Big Wolf are Ponka names; but Young Wolf and Big-wolf In-a-Bad-humor are of the Omaha Wolf gens. Some horse names were originally Wolf names, as, "White Horse" of Omaha Wolf gens, meaning, "White Wolf."[3] Hoof names, in Deer gentes, refer to deer or fawns; in Buffalo gentes, to the buffalo.

Many names are elliptical, hence a knowledge of their respective gentes is of great value. Examples: I-shta du-ba, Four Eyes (of the Omaha Black-bear sub-gens), refers to the true eyes and the yellow spots resembling eyes, over the eyes of a bear. I-shta ba-su-de (of an Omaha buffalo gens), Sheds hair next to the eyes, *i. e.*, a buffalo calf. I-iñ-ga-bi, Despised (of the Deer gens), *i. e.*, the fawn is despised by the hunter, who prefers to shoot the

[3] The names of horse and wolf are derived from that of "dog."

mother. Ki-da-ba-zhi, Not shot at (of the Deer gens), *i. e.*, the fawn is not shot at, its mother being preferred by the hunter.

Shu-de-na-zi, Smoked Yellow (of the Omaha Hañ-ga gens), refers to the sacred pole of the gens. Shu-de-ga-ghe, Smoke Maker, refers to a war custom.

Mythical names abound in the languages of the Siouan tribes.

The writer has found a key to some of them in the myths of the Osages, Kansas, and Omahas, and in the traditions of the Iowa, Kansas, and the Osage Tsi-shu-wa-shta-ke gens. Many Raccoon names found in the Kansas Raccoon gens occur in the myth of the Raccoons and the Crawfish.[4] In the Kansas tradition of their origin, as preserved in the secret society of the tribe, it is said that at the first I-ba-ch'ĕ (now Raccoon) people had no sacred animal, so they went in search of one. They killed a raccoon, and as it lay on the ground, one said, "See! let this be our sacred animal. Let us take names from it!" Hence the names: Sharp Claws, Black stripe across the eyes, Blue Back, etc. In the Oto Bear gens is "Blisters the feet." It is explained by the speech of the Black bear in the Osage tradition:

"Sha'-ke tsü'-tse wa-dha'-kshi-dhe' ta-tse', a'-pi^{n}-tau', Tsi-ka'!
Claw blister you cause purposely shall he said indeed O grandfather!

You shall cause me to blister my feet in your service: he really said, O Grandfather!

The Oto "Walks a long time" points to the journey of the two old Osage men of the Tsi-shu and Ponka gentes, who went for seven days in search of a good land for the nation. The Oto "Big Cedar" is probably derived from the mystic tree of life of the secret order, symbolized by the cedar. The name Ponka is associated with this tree. The Iowa "Small Island" is explained in the tradition of that tribe. Of female names, the Omaha "She by whom they were made human beings" clearly points to the Osage female red bird brooding on her nest, who gave human bodies to the people. Clear sky Female refers to the beautiful day when they came down to this earth from the four (or seven) upper worlds. The Ponka Dhighida gens has the name Nini-ukhdhi giuda^{n}, She who likes to eat the grasshopper called nini-ukhdhi. It is explained by the Osage myth, which

[4] Pub. in Amer. Antiquarian, July, 1884. pp. 237–40.

tells how this grasshopper (Na-khdhe sha-pe) was eaten by his grandmother.

Te-wa 'u (Buffalo Woman) and Te mi^{n} wa-'u (Buffalo Female Woman) are distinct from Buffalo Female. And these must not be confounded with female buffalo (te-mi^{n}-ga). The adventures of the Orphan and the Buffalo Woman have been recorded by the writer in three Omaha versions. In the Ponka Hisada gens these names occur: He-who-Runs-Close, Prairie-chicken-Usually-Coming, Runs-on-the-Water, Habitual Eagle, Spoken to (in thunder), Water-monster, and Eagle Circles-around. These are explained by the myth of the first Hisada chief, Ukiabi (*Spoken to*). He had a nose resembling that of a hawk which catches small birds. His eyes were deep in their sockets. He was very lean, and horrible to look at. One day he was reclining in his lodge. Looking up through the smoke-hole, he spied an *eagle circling around.* This he recognized as his son, who usually (*habitually*) *took this shape.* The eagle, on finding that he was detected, darted down to attack his father. But Ukiabi fled. His son *ran so close* to him that Ukiabi changed his form to escape. But the son took a similar shape, and subsequently imitated each transformation of the father. At last, Ukiabi left the land and *ran on the surface of the water*, but the son did likewise. Next Ukiabi went beneath the water, becoming a *water monster;* but the son still followed. Returning to the air, the father became an eagle once more, soaring aloft, and looking around for his son. Presently he spied a feather on the ground. It was his son. Down he swooped, and as he passed it he gave it a blow with his wing, and then flew aloft. Behold, his son lay dead in his proper shape! Then the father sang a dirge over the body, the words of which are still preserved by the Hisada people.

THE URINE DANCE OF THE ZUNIS. By JOHN G. BOURKE, Captain Third Cavalry, U. S. Army.

ON the evening of November 17, 1881, during my stay in the village of Zuni, New Mexico, the *Nehue-Cue*, one of the secret orders of the Zunis, sent word to Mr. F. Cushing (whose guest I was) that they would do us the unusual honor of coming to our house to give us one of their characteristic dances, which, Cushing said, was unprecedented.

The squaws of the Governor's family put the long "living room" to rights, sweeping the floor and sprinkling it with water to lay the dust. Soon after dark the dancers entered; they were twelve in number, two being boys. The centre men were naked with the exception of black breech-clouts of archaic style. The hair was worn naturally with a bunch of wild turkey feathers tied in front, and one of corn-husks over each ear. White bands were painted across the face at eyes and mouth. Each wore a collar or neck-cloth of black woollen stuff. Broad white bands, one inch wide, were painted around the body at the navel, around the arms, the legs at mid-thighs and knees. Tortoise-shell rattles hung from the right knee. Blue woollen footless leggings were worn with low cut moccasons, and in the right hand, each waved a wand made of an ear of corn, trimmed with the plumage of the wild turkey and macaw. The others were arrayed in old cast-off American army clothing, and all wore white cotton night-caps, with corn-husks twisted into the hair at top of head and ears. Several wore, in addition to the tortoise-shell rattles, strings of brass sleigh-bells at knees. One was more grotesquely attired than the rest in a long, India-rubber gossamer "over all" and a pair of goggles, painted white, over his eyes. His general "get-up" was a spirited take-off upon a Mexican priest. Another was a very good counterfeit of a young woman.

To the accompaniment of an oblong drum, and of the rattles and bells spoken of, they shuffled into the long room, crammed with spectators of both sexes, and of all sizes and ages. Their song was apparently a ludicrous reference to everything and everybody in sight, Cushing, Mendeleff and myself receiving special attention, to the uncontrolled merriment of the red-skinned listeners. I had taken my station at one side of the room, seated upon the banquette, and having in front of me a rude bench or table upon which was a small coal-oil lamp. I suppose that in the

halo diffused by the feeble light and in my "stained-glass attitude," I must have borne some resemblance to the pictures of saints hanging upon the walls of old Mexican churches; to such a fancied resemblance, I at least attribute the performance which followed.

The dancers suddenly wheeled into line, threw themselves on their knees before my table, and with extravagant beatings of breast, began an outlandish but faithful mockery of a Mexican Catholic congregation at vespers. One bawled out a parody upon the Pater Noster, another mumbled along in the manner of an old man reciting the rosary, while the fellow with the India-rubber coat jumped up, and began a passionate exhortation or sermon, which for mimetic fidelity was inimitable. This kept the audience laughing with sore sides for some moments, until at a signal from the leader, the dancers suddenly countermarched out of the room, in single file, as they had entered.

An interlude followed of ten minutes, during which the dusty floor was sprinkled by men who spat water forcibly from their mouths. The *Nehue-Cue* reëntered; this time two of their number were stark naked. Their singing was very peculiar and sounded like a chorus of chimney-sweeps, and their dance became a stiff-legged jump, with heels kept twelve inches apart. After they had ambled around the room two or three times, Cushing announced in the Zuni language that a "feast" was ready for them, at which they loudly roared their approbation and advanced to strike hands with the munificent "Americanos," addressing us in a funny gibberish of broken Spanish, English, and Zuni. They then squatted upon the ground and consumed with zest, large "ollas" full of tea, and dishes of hard tack and sugar. As they were about finishing this, a squaw entered, carrying an "olla" of urine, of which the filthy brutes drank heartily.

I refused to believe the evidence of my senses, and asked Cushing if that were really human urine. "Why, certainly," replied he, "and here comes more of it." This time it was a large tin pailful, not less than two gallons. I was standing by the squaw as she offered this strange and abominable refreshment. She made a motion with her hand to indicate to me that it was urine, and one of the old men repeated the Spanish word *mear* (to urinate), while my sense of smell demonstrated the truth of their statements.

The dancers swallowed great draughts, smacked their lips, and,

amid the roaring merriment of the spectators, remarked that it was very, very good. The clowns were now upon their mettle, each trying to surpass his neighbors in feats of nastiness. One swallowed a fragment of corn-husk, saying he thought it very good and better than bread; his vis à vis attempted to chew and gulp down a piece of filthy rag. Another expressed regret that the dance had not been held out of doors, in one of the plazas; there they could show what they could do. There, they always made it a point of honor to eat the excrement of men and dogs.

For my own part I felt satisfied with the omission, particularly as the room, stuffed with one hundred Zunis, had become so foul and filthy as to be almost unbearable. The dance, as good luck would have it, did not last many minutes, and we soon had a chance to run into the refreshing night air.

To this outline description of a disgusting rite I have little to add. The Zunis, in explanation, stated that the *Nehue-Cue* were a Medicine Order which held these dances from time to time to inure the stomachs of members to any kind of food, no matter how revolting. This statement may seem plausible enough when we understand that religion and medicine among primitive races are almost always one and the same thing, or at least so closely intertwined that it is a matter of difficulty to decide where one begins and the other ends.

Religion in its dramatic ceremonial preserves, to some extent, the history of the particular race in which it dwells. Among nations of high development, miracles, moralities and passion plays have taught, down to our own day, in object lessons, the sacred history in which the spectators believed. Some analogous purpose may have been held in view by the first organizers of the urine dance. In their early history, the Zunis and other Pueblos suffered from constant warfare with savage antagonists and with each other. From the position of their villages, long sieges must of necessity have been sustained, in which sieges, famine and disease, no doubt, were the allies counted upon by the investing forces. We may have in this abominable dance a tradition of the extremity to which the Zunis of the long ago were reduced at some unknown period. A similar catastrophe in the history of the Jews is intimated in II Kings, xviii, 27. "But Rab-shakeh said unto them: hath my master sent me to thy master, and to thee to speak these words? hath he not sent me to the

men which sit on the wall, that they may *eat their own dung and drink their own piss* with you?" In the course of my studies, I came across a reference to a very similar dance, occurring among one of the fanatical sects of the Arabian Bedouins, but the journal in which it was recorded, the London Lancet I think, was unfortunately mislaid.

As illustrative of the tenacity with which such vile ceremonial, once adopted by a sect will adhere to it and become ingrafted upon its life, long after the motives which have suggested or commended it have vanished in oblivion, let me quote a few lines from Max Muller's "Chips from a German workshop," "Essay upon the Parsees," pp. 163-164, Scribner's Edition, 1869.

"The *Nirang* is the urine of cow, ox or she-goat, and the rubbing of it over the face and hands is the second thing a Parsee does after getting out of bed. Either before applying the *Nirang* to the face and hands, or while it remains on the hands after being applied, he should not touch anything directly with his hands; but, in order to wash out the *Nirang*, he either asks somebody else to pour water on his hands, or resorts to the device of taking hold of the pot throngh the intervention of a piece of cloth, such as a handkerchief, or his *sudra*, *i. e.*, his blouse. He first pours water on his hand, then takes the pot in that hand and washes his other hand, face and feet." (Quoting from *Dadabhai-Nadrosi's* Description of the Parsees.)

Continuing, Max Muller says: "Strange as this process of purification may appear, it becomes perfectly disgusting when we are told that women, after childbirth, have not only to undergo this sacred ablution, but actually to drink a little of the *Nirang*, and that the same rite is imposed on children at the time of their investiture with the *Sudra* and *Koshti*, the badges of the Zoroastrian faith."

The significance of flora to the Iroquois. By Mrs. Erminnie A. Smith.[1]

There are many circumstances which help to prove that in the distant past a certain large stock of Indians, either for their protection in establishing outposts for the acquisition of hunting facilities or for other reasons, became so dispersed as finally to receive at least six different tribal names, and to speak the several dialects, known as the Mohawk, the Oneida, the Onondaga, the Cayuga, the Seneca, and the Tuscarora.

What may have been the original name of their mother tongue, if we may use that affectionate expression, we cannot yet decide. I see no reason why it may not have been their own appellation of themselves at the present time, a name which with slight dialectical differences of sound is common to them all, namely, "Ho-ti-noñ-'syoñ-'nĭ'," or "Extended House," referring to their style of architecture and manner of living.

Most writers upon the Iroquois, however, consider that name to date from a confederacy, reuniting this family, supposed to have been originated by the mythical Haiă-hwă't'-thă.'

From the easily distinguishable resemblances between these dialects, the early French grouped them as the "Iroquois," a word supposed to mimic two very frequent endings common to all the different tribes.

Under the system of Indian nomenclature lately adopted by the Bureau of Ethnology, the term "Iroquoian" has been applied to this group.

In a paper which I had the honor of reading before the Association some years ago, I endeavored to explain some of the differences between the dialects composing this group and some probable causes of the same, but in this brief study, I shall have occasion to note more particularly their marked resemblances, confining my examples within the limited scope of my subject.

In a list containing forty names of trees and plants which I procured from each of the six tribes, more than half have the same name in each one of the dialects.

The differing names are nearly all confined to the Seneca and Cayuga dialects.

[1] This paper is published without revision by Mrs. Smith, whose death, it is my sad duty to announce, occurred on June 9, 1886, at her home in Jersey City.—Editor.

Among the marked resemblances are the following:—

ENGLISH.	TUSCARORA.
Beam Tree,	Nă-rhă′-kwĭ.‘
Beans,	U-Çă‘′-hă-‘rhä, or, Çă‘′-hä‘.
Beech Tree,	U-tckă^{n}rh′-hă.‘
Corn,	U-nä^{n}-‘′hä.
Cranberry,	Tu‘ks′wă‘′-nä^{n}‘.
Cypress,	U-nä‘-tu′-yă‘.
Hemlock,	U-nä^{n}‘′-tă‘.
Hops,	U-tcĭ‘′-tcă‘.
Mulberry,	Çhu‘′-yäç.
Raspberry,	Tsyu-tă‘-kwă-kă′yä^{n}.
Raspberry, Red,	U-nă‘-tcu‘′-kwä.
Rice,	U-nă‘-tcă‘.
Spruce,	U-tcu‘-ku‘′-nä^{n}‘.
Tamarack,	Kă-nä^{n}‘′-t^{n}äç
Tobacco,	Tcărh-hu.‘
White Pine,	U-nä^{n}-tă‘.
White Cedar,	U-çu‘-rhă‘′-tă‘.
Wild Cherry,	Ä′-rhĭ‘.
Winter Green,	Kă-nă-kä^{n}‘să′-krhăç.
Turnip,	U-bcĭ‘′-kwă.‘

These then are pure Iroquoian words, souvenirs of prehistoric forests where the crack of a rifle was unheard and unknown, and of a time when special uses and qualities, fanciful ideas, or supposed resemblances were the science of nomenclature.

Though unwritten, can this Iroquoian language properly be termed "prehistoric" when even its isolated words represent beautiful thoughts and images, and are in themselves a history, and representatives of the mode of thought in that distant age, when they were spoken?

Let us decipher a few of these ancient words and compare them with as many in English, and they will reveal to us at least the sameness in the underlying structure of languages, whether they be high up or low down on the rounds of the ladder of development.

To the native Iroquois the white ash was the bow tree and the black ash the canoe tree, implying that from these two trees were fashioned those indispensable articles.

The elm tree was the symbol of grace, and happy the Iroquoian maiden who in her childhood had drunk of its sap, and was therefore destined to be as stately.

The spruce was named from its erect cones; the apple was the large fruit. The original meaning of the strawberry is unknown, but a pineapple is now termed "large strawberry."

Water melon translates "It sheds its blush," and musk melon "ripening fruit." Corn means seed, marking it as having been at some period their only agricultural product. This is further proven from the fact that corn has in the Iroquois a verb "to plant" of its own which is in reality the name of the famous Cornplanter, the word "corn" not being present in that proper name. Wintergreen translates pleasant odor, and the word for cranberry imitates the sound which is made when picking this fruit.

We may not find in this nomenclature the poetry of many of our own floral names, such as "eyebright," "bluebell," "maiden's hair," "lady slipper," and some others. But may there not be many Iroquoian words whose literal meanings are as beautiful, though now as unknown to those who use them as is Chaucer's "Day's-eye" to many English speaking people who to-day find no sentiment in the word daisy?

We find in Iroquois many homonyms the explanations of which are very curious. Our dandelion anglicised from the French *dent de lion* (lion's tooth), alluding to the shape of its petals, is in Tuscarora, Kă'-rhă, and, coming simultaneously with the sturgeon is said to announce its arrival and is therefore called by the same name as that fish. Correspondingly in English we have the "Cuckoo flower," so called because this orchis blossoms about the time that the cuckoo is first heard.

The Iroquois find a resemblance between the cucumber and the warty toad, and they have the same name; and the words for turnip and fist are alike.

Many homonyms in English arise in the same manner, from similar resemblances; for examples, dock is from the Icelandic docke, a tail, to cut short, and dock is a taprooted plant, or plant with a tail; also flag to grow weary, from moving to and fro, so flag an ensign which moves in the wind, and flag, a plant from its waving motion.

The witch hazel in Tuscarora is named from its pith, the alder from its lack of it. Oats in Mohawk are named from their droop-

ing tendency which reminds us of the poetical German name "golden rain," given to our drooping laburnum.

The quantities of blueberries growing upon the Alleghanies gave their name to those mountains. The word Erie is also Iroquoian, named from its being the locality where wild cherries abounded.

The reflection of the trees in the lake at Toronto gave that city the Iroquois name which it still bears. How familiar is this system of nomenclature to those interested in the origin of names!

Madeira was named by the Portuguese from its great forests; the classic name Peloponnesus was changed to Morea from the resemblance of that region to the shape of a mulberry leaf, and the meaning of Florida is familiar to all.

The synonyms of the Iroquoian group probably date from their separation into tribes. Words occur among the different tribes which are radically different but which have the same literal meaning. Thus in Tuscarora a head of cabbage is u-tă'-rhä', while in Mohawk the word o-noñ'-tci means literally the same thing, —head.

In Tuscarora, wăt-ä^{n}'-rhä^{n}·'-ih-thă', signifying the poplar, translates literally, "its wings (its leaves)" up and down, while in the Mohawk wă-ne-ră-toñ'-'thă, signifies the same thing.

That the Tuscarora name for the pear is quite modern is amusingly apparent. The word for bear in that dialect is u'-tci''-rhä^{n}'; having no labials in Tuscarora, and mistaking the "p" for a "b," thus supposing the English called the fruit a bear, they applied to it their own name for that animal, u'-*tcĭ*''-rhä^{n}'.

The Iroquois appellations for flowers are often used for feminine proper names, as *A-woñ-ne-oñt*, hanging flower; Kă-tcĭ'-tcĭ'-*stă'-kwăst*, beautiful flower; while trees and their qualities often serve for masculine proper names. This practice of surnaming girls after flowers and beautiful objects is quite common to us and is of very ancient date, but it is noticeable that in modern times more plants have been named after men than contrariwise, as the Gentian from Gentius, Dahlia after Dahl, a Swede who introduced its cultivation, Fuchsia named after Fuchs, Magnolia after Magnol, while the Camellia received its name from being introduced from Japan into Europe by Camellus, a Moravian Jesuit.

That an original name in Iroquois has often been transferred to

other than the original object, is verified by examples like the following:—

U-näñⁿ-ça'	= potato	in Tuscarora.
O-noñ-să	= onion	" Onondaga.
Wĭ''-säⁿñt	= strawberry	" Tuscarora.
Wis	= plum	" Onondaga.

Something corresponding to this is the case with the German word, *tartuffle*, given to the potato on account of its resemblance to their tartoffle or truffle. They have since changed the t into a k, making kartoffle.

These analogies might be carried much farther if the subject were extended outside the chosen limit of Flora, but I doubt if any other subject would be as fruitful in producing examples capable of comparing favorably with those selected from a language into whose treasury all civilized nations have lavished their contributions.

There was much in nature incomprehensible to the Iroquois mind but not so were the forest trees. They were his guide, his friends and companions, and all vegetation served to supply so many of his wants that we find the six religious festivals of the Iroquois principally devoted to giving thanks for the maple, strawberry, green corn, bean and squash, calling them "Our life, our supporters;" whilst tobacco was continually thrown upon the fire that their prayers might ascend in its cloud of smoke.

The most striking metaphors of the Iroquoian orators were those in which they likened themselves to the forest trees. To a friend who called upon the great Oneida chief *Skäⁿ-näⁿ''doñ'* a short time before his death, he expressed himself thus: " I am an aged hemlock, the winds of a hundred winters have swept through my branches. I am dead at the top. The generation to which I belonged has run away and left me. Why I live the Great Spirit knows. Pray to him that I may have patience to wait my appointed time to die."

A lady who knew the fondness of the famous Red Jacket for children inquired of him if he had any living, as she knew that several had been taken away. Fixing his eyes upon her with a mournful expression, he replied: " Red Jacket was once a great man, and in favor with the great spirit. He was a lofty pine among the smaller trees of the forest. But after years of glory he degraded himself by drinking the fire water of the white man.

The Great Spirit has looked upon him in anger, and his lightning has stripped the pine of its branches."

The early youth of this great orator was spent in the beautiful valley of the Genesee. There were his favorite hunting grounds. There his memory loved to linger. During the strife of wars and the more bitter strife of treaties, he had indulged very little in his favorite pastime, but when a day of comparative quiet came, he took his gun and went forth in the hope of finding a deer. He had gone but a short distance, when a clearing opened before him; the old man turned aside and wandered in another direction, but soon came to a place where the white man was turning the earth up in dark furrows over a large field. It was then that he sat down upon a fallen oak and wept bitter tears, that the haunts of his youth were being despoiled of all that had rejoiced the heart of his childhood and manhood.

The medicinal properties of plants and roots were understood by the Iroquois, and although the knowledge was principally confined to the "medicine men," we find in the myths many allusions to the wonderful cures produced by the use of even the simplest vegetable remedies.

The origin of medicine among the Tuscaroras was related to me as follows by Chief John Mountpleasant of the Bear clan:— Once upon a time a sickly old man, covered with sores, entered an Indian village where over each wigwam was placed the sign of the clan of its possessor; for instance, the beaver skin denoting the Beaver clan; the deer skin the Deer clan. At each of these wigwams the old man applied for food and a night's lodging, but his repulsive appearance rendered him an object of scorn, and the Wolf, and the Tortoise and the Heron had bidden the abject old man to pass on. At length, tired and weary, he arrived at a wigwam where a bear skin betokened the clanship of its owner. This he found inhabited by a kind-hearted woman who immediately refreshed him with food and spread out skins for his bed. Then she was instructed to go in search of certain herbs, which she prepared according to his directions, and through their efficacy he was soon healed. Then he commanded that she should treasure up this secret. A few days after, he sickened with a fever, and again commanded her to search for other herbs, and was again healed. This being many times repeated, he at last told his benefactress that his mission was accomplished, and that she was now endowed with all the secrets

for curing disease in all its forms, and that before her wigwam should grow a hemlock tree whose branches should reach high into the air above all others, to signify that her clan should increase and multiply and that the bear should take precedence of all other clans.

The "origin of medicine" among the Senecas is as follows:— Nearly two hundred years ago, a man went into the woods on a hunting expedition. He was quite alone. He camped out in a field and was wakened in the night by the sound of singing and a noise like the beating of a drum. He could not sleep any more, so he arose and went in the direction of the sound. To his surprise the place had all the appearance of being inhabited. On the one hand there was a large squash vine with three squashes on it, and on the other a hill of corn. And three ears of corn grew apart from all the others. He was unable to guess what it meant, but started off on his hunting once more, determined to return some evening, being both curious and uneasy. In the night as he slept near by he heard again a noise, and awaking, saw a man looking at him, who said, "Beware! I am after you; what you saw was sacred; you deserve to die." But the people who now gathered around said they would pardon it, and would tell him the secret they possessed. "The great medicine for wounds," said the man who had awakened him, "is squash and corn; come with me and I will teach you."

He led him to the spot where the people were assembled, and there he saw a fire and a laurel bush which looked like iron. The crowds danced around it, singing and rattling gourd shells, and he begged them to tell him what they did it for, then one of them heated a stick and thrust it right through his cheek, and then applied some of the medicine to prove to him how quickly it could heal the wound. Then they did the same to his leg. All the time they sang a tune, they called it the "medicine song," and taught it to him. Then he turned to go home, and all at once he perceived that they were not human beings but animals, bears, beavers and foxes, which all flew off as he looked. They had given him directions to take one stalk of corn and dry the cob and pound it very fine, and to take one squash, and cut it up and pound that, and they then showed him how much for a dose. He was to take water from a running spring, and always from up the stream, and never down. He made up the prescription and used it with very

great success, and made enough before he died to last over one hundred years.

This was the origin of the great medicine of the Senecas. The people sing over its preparation every time the deer changes his coat, and when it is administered to a patient, they sing the "medicine song," while they rattle a gourd shell as accompaniment and burn tobacco. Burning tobacco is the same as praying. In times of trouble or fear after a bad dream, or any event which frightens them, they say, "My mother went out and burned tobacco."

The medicine is prepared now with the addition of meat.

Numerous are the Iroquois legends regarding the Flora surrounding them.

I will close with the origin of the pond lily from the Huron-Iroquois to which Aldrich in poetizing has added if possible another tint.

Young Wă'-wăh had been killed in the war, Miăntowonă, his love, stoically heard of his death and meekly continued her care of an aged father. But when the old man died she wept not, and while the mourners were chanting the dirges she stole from among them toward the bright water, but Nă-hă'-ho who had long loved her in secret quickly pursued her to the river bank—

"What did he see there
Could so appall him?
Only a circle
Swiftly expanding,
Fading before him.
But as he watched it
Up from the centre
Slowly superbly
Rose a Pond Lily."

BURIAL CUSTOMS OF OUR ABORIGINES. By HENRY GILLMAN, Detroit, Michigan.

IN a paper[1] read before the American Association, at the Detroit meeting, August 16, 1875, extended mention is made by the

[1] "The Ancient men of the Great Lakes," by Henry Gillman: Proceedings of the American Association, 1875.

writer of the peculiar custom of perforating the human skull after death. The discovery of the custom, which seems to be associated with some interesting and curious superstition of the early inhabitants of this country, was made in the year 1869, when I exhumed from the Great Mound on the Rouge River, Michigan, the fragments of two skulls each of which presented the peculiarity. As additional material and facts were accumulated by me, in the course of my investigations, I continued to disseminate the information through various scientific channels,[2] to which it is unnecessary I should do more than simply refer. Lately, in the American Naturalist, I gave a description of perforated crania recently taken from mounds on the Detroit River. In exhibiting to the Association two specimens of those skulls, I shall take occasion to allude to or describe some of the burial customs of our native Indian tribes which have come under my personal observation, and which may be calculated to throw some light on the very remarkable custom of which these skulls are an illustration.

In the first of these fragmentary crania, the cephalic index would throw it into the medium or orthocephalic group, or, to follow the nomenclature of Prof. Broca, the mesaticephalic division. The single circular perforation occupies, as usual, a central position at the vertex of the skull, being situated on the sagittal suture, about 0.6 of an inch back of its junction with the coronal suture. The perforation is 0.4 of an inch in diameter, and was probably made in the same manner as were all those I have seen, by a rude stone implement rotated by hand.

The second specimen is evidently not of as great antiquity as the first. Its fragmentary condition, the occipital bone and parts of the parietal bones, etc., being wanting, prevents taking most of the usual measurements but though a smaller and narrower skull than the first mentioned, its cephalic index would, doubtless, place it in the same range, viz., that of the medium or mesaticephali. It is, however, most interesting in presenting the unusual feature of having two perforations. The smaller of these, less than 0.4 of an inch in diameter, is situated on the sagittal suture, and at a point about 0.1 of an inch back of its junction with the coronal suture.

[2]See "Certain Characteristics pertaining to Ancient Man in Michigan:" Smithsonian Report for 1875. Also "Artificial perforation of the Cranium:" American Naturalist, August, 1875, Vol. ix, p. 473. And "Additional facts concerning Artificial perforation of the Cranium in Ancient Mounds in Michigan," read before American Association, Nashville Meeting, September 4, 1877.

The second perforation is over 0.4 of an inch in diameter, and is placed on the frontal bone, in a straight line with the direction of the sagittal suture, and 0.35 of an inch from its junction with the coronal suture. The perforations, from centre to centre, are 0.8 of an inch apart.

In my examination of these specimens, I have made the important discovery that the perforations in both of them are countersunk, or made from both sides—from the inside as well as the outside of the skull. The bevelled edges unquestionably settle this point, and are a further confirmation, if any such were required, as to the perforations being *post mortem*. This is a point overlooked by me in my previous studies, and, indeed, doubtless is wanting in the perfect crania, where the perforations could not well have been made except from the outside of the bone.

These two specimens present many of the characteristics observed by me in other crania I have taken from our mounds. In the second and narrower skull, the outlines of the orbital cavities, wanting in the first and larger cranium, are decidedly quadrilateral; the frontal protuberances are less pronounced, and the glabella, which in the first specimen is replaced by a slight depression between the superciliary arches, is represented by the usual swelling. The first skull, which is, as I have already stated, the more ancient of the two, is further significantly distinguished by having a small though distinctly developed epactal bone. This bone, sometimes called "the bone of the Incas," from its prevalence in certain ancient Peruvian skulls, I have already called attention to as occasionally pertaining to the more ancient crania from our Michigan mounds; and also to a special inclination (if I may so describe it) to produce this bone, as though at one time some ancestors had possessed this distinctive characteristic, but that the peculiarity, in the later generations, possibly through inimical environment or intermixture with other races, was gradually eliminating.

Both of the specimens seem to have belonged to male adults, as do all others of the perforated skulls which I have observed. The location of the perforation, too, as in all other instances which have come before me, appears not to be governed by the position of the sutures, but only by the object of properly balancing the skull in suspension.

It may be of importance to call attention to the fact that the perforated skulls which have come under my notice do not belong to

any one of the established groups or divisions, but include all. On referring to my tables, I find these crania representing Dolichocephali, Orthocephali or Mesaticephali, and Brachycephali. I may add that skulls belonging to all these divisions, and without being perforated are also found in our Michigan mounds, and sometimes even in the same mound.

As to the superstition and peculiar feelings and motives connected with this custom of perforating the cranium, I must confess I have but little more to say than what I have already given in former papers. The suspension of the head, evenly balanced, was evidently an important part of the design. That the performance of the rite was invariably *post mortem*, and after the flesh had decayed from the bones, and that it was not general, but was reserved for the few, and those adult males, who were specially honored, would seem to be established. In all probability, some religious or superstitious notion was connected with it. Possibly it may have reference to the belief in the immortality of the soul.

It is singular that, notwithstanding the extensive researches among the burial mounds of this continent, the custom, so far, appears to be confined to this region and the State of Michigan, if we except one isolated instance, from California, perhaps not as clearly substantiated as could be wished. The pierced skulls recently brought to light from Ohio mounds, so far as I understand, present a totally different kind of perforation, and cannot be classed with these.

It may well be asked: If our native Indian tribes are the descendants of this people, why do we not see some traces of the custom among them?

The crania and other bones taken from adjoining mounds are of considerable interest, though some of them are evidently not of as great antiquity as the perforated skulls. The accompanying utensil made from a shell of the genus Busycon, which must have been brought from the seacoast, probably once formed the bowl of a spoon. It was taken with some human bones from an adjacent mound. The holes at one end of the utensil, four in number, and in arc like arrangement, seem to have been made for its attachment to the handle, which has long ago decayed. It appears to have been smeared with paint, perhaps at the time of burial, as the adherent sand would indicate. Its size, nearly four inches long by three and a half inches wide, and over three-fourths of an inch

deep, would have constituted it an effective spoon or ladle. But it may have been used as an ornament for the person, and this would the more readily account for its being deposited with the deceased owner. In this latter case the holes would have been for the purpose of attaching it to the person: though the necessity of so many is not obvious. Among the pottery exhumed was a curiously shaped vase of large size, marked with various indented lines, the cord pattern, as usual, predominating.

Among other burial customs brought to light by the exploration of our mounds, few are so clearly established by the investigations of the writer as that of cremation. Long before the time of interment of these perforated crania, that the habit of incinerating the remains of the dead prevailed among the ancient people of this region, has been incontestably proved. The custom seems to have gradually sprung up, and then to have been generally adopted, finally apparently abruptly ceasing to be practised, when ordinary interments, or those in a sitting posture were returned to. Then came the burials among which are found perforated crania, which are succeeded by later burials without this mark.

Some of these changes may betoken the driving out of one race or tribe, and the substitution of another. Few customs are more rigidly adhered to than those pertaining to sepulture. In many parts of Great Britain and Ireland, to this day, it is considered the proper thing to enshroud the dead with flannel, and to allow a small part of the winding sheet to protrude from under the coffin lid: though the law, enacted under Charles II, which compelled the use of flannel for this purpose, and this strange evidence of compliance with it, in order to encourage the manufacture of woollens, has long been done away with.

The remarkable isolated instance of cremation found at the base of the mound within the enclosure of Fort Wayne, on the Detroit River,[3] is of great value as so clearly determining the point that the mound was erected to the individual whose incinerated remains, together with copper knife and other utensils, were deposited in the burial urn. It is remarkable that in most of the subsequent interments in the mound, cremation was not resorted to.

Indications of food, in the shape of bones of birds, fish, etc., left

[3] See paper, "Investigation of the Burial Mound at Fort Wayne, Detroit River," by Henry Gillman. Read at the Buffalo Meeting of the American Association.

to provide for the departed on his journey to the unseen world are of frequent occurrence in the mounds. So are the imperishable stone implements of various kinds. There are few of these burial customs but have reference to the immortal life. And this idea of providing sustenance and comfort for the dead seems to have descended to our contemporary Indians. I have seen their graves on the shores of Lakes Michigan and Huron, and also at Walpole Island, St. Clair River, and elsewhere, the cedar-bark coverings of which had diamond-shaped apertures, that the soul might pass in and out unhindered. Offerings of various kinds were continually left upon the graves, and consisted generally of berries, beads and tobacco. The Pudding-berry or fruit of the *Cornus Canadensis* L. was a favorite offering; so was tobacco, which was left in entire plugs, and often stuck into the aperture at the end of the grave. Some of the graves were marked at the head by the totem of the deceased. This was usually made of white cedar (*Thuja occidentalis* L.), a thin slat-like stake, about eighteen inches or more in length, about three inches wide at top, and tapering to the bottom to a point, in form resembling the marks used in gardens for the naming of plants. Rather neatly cut or carved on the broader part was the totem, the emblem or insignia of the dead; red ochre being rubbed into the incised lines, and the top and sides of the stake being banded and ornamented with the same pigment. The totems were often quite characteristic, and the designs always distinguishable for the objects they were intended to represent. Some well-known quadruped, bird, fish or reptile was generally chosen. I noticed among them the beaver, crane, sturgeon, and turtle. In some instances several figures of men were added lower down; and these were of the usual rude, conventional type of depicting man common to children who have not learned to draw. There were sometimes as many as seven or more of the figures to which I refer; and I was informed they represented the number of enemies which the deceased had slain in battle.

I shall conclude with mention of one of the most remarkable of the customs connected with death and burial, viz.: the burning of the wigwam or lodge on the decease of an inmate, as practised by the Ojibway Indians. In this, the clothes and other effects of the dead are often if not always included. That the custom is still adhered to, I had once the opportunity of observing, on the south

shore of Lake Superior. On the occasion to which I have reference, a young Indian boy had been accidentally killed by his sister. The father, who could not speak a word except in Ojibway, was at the time employed by me, and, I may add, had shown himself remarkably intelligent, constantly evincing an eager desire to obey me with promptness and to please. He was with me at the instant of receiving the cruel news of his son's death; and I never saw any man display more intense distress and affection than he did. It is popularly believed that Indians have but little feeling. He fled from my side, like a deer, rushing toward his lodge, through swamps and thickets, utterly regardless of self, and as though he could not get soon enough to his dead.

And here, for the honor of the natural man, I wish to state, in passing, that the untutored modesty and purity of this Indian, with regard to the care of his person and otherwise, would have shamed many a white man, even of our better class, in whom are seen too often exhibited the opposite characteristics. Such things are difficult to describe, and especially to write about, and I must content myself with simply saying there was a delicacy and propriety of conduct manifested in this direction, by this unsophisticated Ojibway, with his woodland ways, that I was quite unprepared for.[4]

The intelligence of the fatal accident to the boy had reached us in the evening, about dusk. It was impossible that I could then leave. The next morning, being Sunday, I walked to the lodge, to see the afflicted father; but found scarcely a trace of the wigwam. It had been completely consumed, in compliance with the usage of the tribe; not a particle of it remained that had not been reduced to ashes. On inquiring, I learned that the father and mother had left, with the dead body of their son, for an Indian village and burying-ground several miles away. A new lodge had been erected at some little distance from where the old one had stood; and, to it, the rest of the family, including the sister, who was the cause of the death, and the aged grandmother, who was

[4]Investigations subsequently made by me establish the fact that this trait is not uncommon even among our wild Indians of the far west. I have had more than one instance illustrating it brought to my knowledge. In the case of an Omaha Indian, shot through the heart, in battle, while falling to the earth, in the very act of dying, he was careful to cover his person, readjusting his breech-cloth (always worn by the Indian) for the purpose.

nearly sightless, had removed. The remaining member of the family was a younger brother.

The burning of the wigwam was, of course, with the belief it would provide habitation for the deceased in the other world, and must be accepted, with other similar customs, to some of which I have referred, as strong proof of the faith of the Indian in a future existence.

THE REMAINS AT SAN JUAN TEOTIHUACAN. By AMOS W. BUTLER, Brookville, Ind.

[ABSTRACT.]

TWENTY-SEVEN miles from the City of Mexico is what is left of San Juan Teotihuacan. A little distance from the railroad station, to the northward, may be seen two mounds of great size and rather regular in shape. To reach them one must cross the valley of a small stream, all the time passing over ground thickly studded with mounds and exceedingly abundant in archæological remains. A little over a mile from the station the first pyramid, "The House of the Sun," is reached. Its sides are partially covered with the curious vegetation of the tableland. Its great size is what first attracts the attention of the visitor. According to the best authority at hand two sides of its base are 682 feet long, the other two but little less; while its height is 221 feet. Upon the south is a row of four mounds about equidistant from its base, while to the west are three earthworks arranged along the base with two others but a short distance off. Upon the eastern side of this pyramid is a narrow winding passage, fitted with steps of volcanic stone, leading from the bottom to its summit. Upon the top I discovered several large stones which I connected with the tradition that a temple once occupied this spot. About half a mile to the north and to the south of this pyramid, arranged somewhat in the form of a square, are two groups of mounds. At the base of the "House of the Sun," upon the west side, I noticed an excavation, the credit of which is given to the French. The opening entered the pyramid at an angle of about forty degrees. A

few feet in, a wall was found at the south side of the opening; following this, for about twenty feet, three walls were discovered, parallel to each other and to the base running in a southerly direction. The inmost of these was found to be intersected by another wall thus forming two sides of a chamber of unknown extent. Within the part of this room which was uncovered, I observed a pillar 3½ feet square and 5 feet high. From the south side of this room a passage was found which was only uncovered for a short distance, when the excavation ceased. The walls and pillar spoken of are composed of gravel and volcanic rock united by cement, over which a coating of stucco appears in a good state of preservation. The walls are decorated with figures of human beings, painted in red.

The "House of the Moon" is the name of a smaller pyramid which stands about 1000 yards northwest of the other. The base of this pyramid is 500 feet in length, 426 feet in width, and its height is 137 feet. Both of these monuments have the appearance of truncated pyramids built in three successive terraces. Each terrace recedes about six feet from the edge of the next lower stage, leaving passage ways all around the pyramid. Beginning a short distance from the south side of the pyramid of the moon, a large number of mounds and other earthworks are arranged in two lines parallel to each other, which extend in a southerly direction for a mile or more. Starting from the two southern corners of this pyramid are elliptical embankments of earth, with mounds upon them, which meet these rows of mounds at right angles. The parallel rows of mounds are about 60 feet apart. Between them was a smooth road covered with cement, upon either side of which were lines of steps or seats, also covered with cement. Just above the second terrace, on the side of the pyramid facing this road, is an opening which, after extending downward toward the centre of the structure, terminates in two vertical holes.

Evidently each terrace of these pyramids was constructed separately: that is, the earth of each terrace was shaped and covered with cement before the next stage was begun. When the whole was completed another layer of cement was put over all the stories of the structure. While this last coat was yet soft, either fragments of volcanic rock were laid in it, or else a covering of such rocks had been laid and about them the cement had been poured.

If we consider rudeness and simplicity of structure as evidence of antiquity, these monuments would indicate a period prior to anything which I have seen upon the Mexican plateau, and it would, no doubt, add much to our knowledge of ancient American life should a satisfactory exploration of this region be made.

A VISIT TO THE SILETZ RESERVATION, OREGON. By Rev. J. OWEN DORSEY, Bureau of Ethnology, Washington, D. C.

THE PRIMARY CLASSIFIERS IN DHEGIHA AND COGNATE LANGUAGES. By Rev. J. OWEN DORSEY, Bureau of Ethnology, Washington, D. C.

THE SENECA INDIANS OF WESTERN NEW YORK: THEIR CUSTOMS, LANGUAGE AND LEGENDS. By JOHN WENTWORTH SANBORN, Batavia, N. Y.

LAWS AND TERMS OF KIN AND RELATIONSHIP IN THE OMAHA TRIBE. By FRANCIS LA FLESCHE, Indian Bureau, Interior Department, Washington, D. C. (This paper will be printed in full, with chart, in the Reports of the Peabody Museum, Cambridge, Mass.)

THE SACRED TENT OF WAR AND SOME OF THE WAR CUSTOMS OF THE OMAHAS. By ALICE C. FLETCHER, Peabody Museum, Cambridge, Mass. (This paper will be printed in full in the Reports of the Peabody Museum.)

AN AVERAGE DAY IN A SIOUX CAMP. By ALICE C. FLETCHER, Peabody Museum, Cambridge, Mass. (Printed in full in Science for Oct. 2, 1885.)

THE STONE AXES OF THE CHAMPLAIN VALLEY. By Prof. G. H. PERKINS, Burlington, Vt. (Printed in full in American Naturalist for Dec. 1885).

ON CERTAIN SINGULAR STONE IMPLEMENTS FROM VERMONT. By Prof. G. H. PERKINS, Burlington, Vt.

EXHIBITION OF SPECIMENS FROM MOUNDS AT GRAND RAPIDS, MICHIGAN. By W. L. COFFINBERRY, Grand Rapids, Michigan. (Portions of this paper will be given, with illustrations, in the Reports of the Peabody Museum.)

WHO MADE BELT WAMPUM? By Mrs. ERMINNIE A. SMITH, Jersey City, N. J.

EXPLORATIONS OF INDIAN MOUNDS IN DAKOTAH. By Hon. WILLIAM MCADAMS, Alton, Ill. (To be printed in the American Antiquarian.)

ANCIENT PICTOGRAPHS IN ILLINOIS AND MISSOURI. By Hon. WILLIAM MCADAMS, Alton, Ill. (To be printed in the American Antiquarian.)

EXPLORATIONS IN THE GREAT CAHOKIA MOUNDS. By Hon. WILLIAM MCADAMS, Alton, Ill.

EFFIGY MOUNDS OF WISCONSIN. By Dr. WILLS DE HASS, Washington, D. C.

AMERICAN ARCHÆOLOGY: PROGRESS OF DISCOVERY. By Dr. WILLS DE HASS, Washington. D. C.

THE PROPER METHODS OF EXPLORING MOUNDS, BURIAL PLACES, AND VILLAGE SITES. By F. W. PUTNAM, Peabody Museum, Cambridge, Mass. (The substance of this paper is given in the Johns Hopkins University Circular for May, 1886.)

EXHIBITION OF ORNAMENTS MADE FROM PIECES OF HUMAN CRANIA; FROM A MOUND IN OHIO. By Dr. C. L. METZ, and F. W. PUTNAM, Peabody Museum, Cambridge, Mass. (These specimens will be described and figured in the Reports of the Peabody Museum.)

THE DEGENERACY OF RACES. By WILLIAM ZIMMERMAN, Chicago, Ill.

ARE CONTEMPORARY PHANTASMS OF THE DEAD TO BE EXPLAINE PARTLY AS FOLK-LORE? By Dr. CHARLES SEDGWICK MINOT, Boston, Mass.

THE NUMBER HABIT. By Dr. CHARLES SEDGWICK MINOT, Boston, Mass.

A SUPPOSED NATURAL ALLOY OF COPPER AND SILVER FOUND ON THE NORTH SHORE OF LAKE SUPERIOR, IN MINNESOTA. By Prof. N. H. WINCHELL, Minneapolis, Minn.

MUSIC IN SPEECH. By M. L. ROUSE, Toronto, Canada.

SECTION I.

ECONOMIC SCIENCE AND STATISTICS.

ADDRESS

BY

EDWARD ATKINSON.

VICE PRESIDENT, SECTION I.

THE APPLICATION OF SCIENCE TO THE PRODUCTION AND CONSUMPTION OF FOOD.

LADIES AND GENTLEMEN:—I have been called to preside over your Section at the present meeting without having had any previous experience in the conduct of the work; I have, therefore, been somewhat at a loss as to what might be my duties or my privileges; but as soon as I began to consider the object of the Association the way became very plain.

If I rightly comprehend this purpose it is not to popularize science by lowering its standard, but it is to bring the progress of science and art in their application to human welfare, prominently before the public and to bring together all who have even a moderate knowledge of the sciences; while at the same time rendering it easier for all who are engaged in the higher branches of scientific research to coöperate together,— to confer with each other,— and to aid each other in those preliminary investigations which must often take many, many years before their results can be applied to the material welfare of humanity.

Give all the credit that we may or which is due to those who engage in the pursuit of knowledge or in the evolution of science for its own sake; yet, in one way or another, their work may finally rest, for its justification, upon its influence on the material welfare of the race. We are all members one of another, and the word which the Philistine may whisper to the Children of Light might be something like this: "Our Section I may be only the bread and butter section; we may deal only with the prosaic subject of providing food, shelter and clothing; we may be only trying to find out how to save a few dollars' worth more or less to the

community, but what would become of all the rest of you without us?" Like other men, our scientific brethren must be provided for and sustained. Would that they were more fully sustained, and that their modicum of food, fuel, shelter and clothing could be supplied to them in greater measure and on less arduous and penurious conditions than these under which they are sometimes forced to work.

Perhaps we may open the way for more adequate provision for the higher branches of scientific research, if we connect it directly with the subjects which belong especially to our own section. Can we not prove, so that he who runs may read, that the only safety is in science and that the so-called "practical man" who distrusts its teachings is the most unpractical of mere theorists? Is he not often the man who thinks he knows everything from his own insufficient observations and yet is utterly ignorant even of the simplest principles of his own art?

To this end the direction of this address will be devoted mainly to opening the subject of the future applications of science to the production and use of food.

What is the present daily ration of the working men and women who constitute the vast majority of the people of this and other lands?

What does it cost them in money or in labor?

What might be the daily ration if the science of nutrition could be made a part of the common knowledge?

How much could its cost be reduced, and its nutritious properties increased?

In preparation for this meeting I have endeavored to bring into clear view the vast changes, both social and scientific, which have rendered the production and distribution of all commodities, and especially of food, so much easier and more equitable during the present generation than ever before. I have also endeavored to forecast, as far as we may, that further progress which may be immediately before us, perhaps to be completed before the end of the present century in some special directions, such as in the division of the electric current, or in securing a supply of nitrogen at low cost in agriculture.

I shall endeavor to demonstrate to you that in the generation which will have passed between the end of our civil war and the beginning of the next century, greater progress will have been

made in the way of material welfare, that is to say, in the production and more equal distribution of wealth, than in any preceding period of the same term, and perhaps more than in any preceding century since history began to be written.

The true beginning of the economic history of this country may hereafter be dated from the year 1865; that is to say, from the end of the active war in which the passive war of slavery culminated and by which it destroyed itself.

I present this great social change as of the first importance, in its influence upon the economic history, not only of this country, but of the world. To the English-speaking people seems to have been given the power of extending their influence and their institutions over every part of the globe. It has been clearly pointed out by Prof. Seeley, that while greater Germany, greater Portugal, greater France and greater Spain have almost ceased to exist, greater England continues to expand. Already the English-speaking people of the United States outnumber those of Great Britain and all her colonies. What is the force which enables the English State to exist, to expand and to dominate all others? What is the essence of the common law of England? Is it not the spirit of individual liberty? When slavery attempted to dominate, it destroyed itself in conflict with the very principle of liberty on which this nation was founded by Washington, Jefferson, Laurens and Patrick Henry of the south as truly as by Hancock, Adams, Hamilton and Franklin of the north.

Only within the last twenty years has it been possible for any one of us to speak of our country as a land of liberty without a blush of shame. Yet so completely has this change been effected as to have enabled me to say to our southern brethren, with their hearty approval, that so absolute has been the revolution not only in their institutions but in their ideas, that it would take a greater war to reimpose the burden of slavery upon them than it did to destroy it; and I added that the time may not be far distant when the descendants of confederate soldiers will erect a monument to John Brown upon the heights of Harper's Ferry, in commemoration of the liberty which he gave to the whites of the south when he fired the first shot for the freedom of the blacks.

Coupled with this great social change have come such material changes that I think it is perfectly safe to say that "*Uncle Sam*," considered as a concrete individual can do at least a third more

work in the same number of hours and can produce a third more product measured by quantity in ratio to a given amount of labor than was possible for him to produce and distribute twenty or twenty-five years ago.

My chief purpose in this address is, first, to pass in review these other changes, aside from the destruction of slavery, which have been brought about by the advancement of science, by means of which the necessary struggle for life has been so greatly lessened and the abundance, especially of food, has been so vastly increased. I shall then endeavor to forecast the future in such a way as will at least give a dim perception of what the next century may have in store for our children, if the inventions or discoveries, which now seem to be on the very edge of being perfected, shall be presently completed.

In the course of less than this single generation which will have passed between the date when peace had become established and the unity of this nation had been assured by the removal of the only cause of disruption, mankind, as a whole, will also have gained greater power over the forces of nature and will have reduced the effort necessary to secure a comfortable subsistence in greater measure than in any other similar period in the recorded history of the world: not even excepting the generation in which the smelting of iron with mineral coal was first discovered, in which period the steam engine was also invented; or that in which the modern textile factory, the railway and the locomotive engine were first put to use; or that in which the steamship and the telegraph wire first crossed the ocean.

Perhaps the only period which can be compared with the present in the importance of the new forces placed at the use of man, would be that in which gunpowder was invented. This invention was of supreme importance in economic history. It finally completed the change in the method of the distribution of wealth from status to contract. It affected society more profoundly than any other invention ever made, because it rendered the weak man equal to the strong man. It destroyed the power of the man clad in armor to secure wealth without work. It made modern mining possible, rendering metals abundant. It equalized the conditions of men without regard to superior strength. It substituted brain for muscle; and it finally turned the scale between despotism and freedom, by rendering individual liberty possible.

It is I think commonly assumed that the invention of the steam engine, the spinning frame and the power loom, which came nearly together, made greater changes in the production and distribution of wealth, perhaps in a single half-century, than ever occurred before or since; but you will observe that the force of steam was substantially limited during the first half-century of its application, to reducing the cost of labor in making textile fabrics for clothing and in working metals, but that it has only been in recent years that it has exerted any great influence in respect to the production or distribution of food.

Now, important as clothing may be, it is relatively unimportant as compared to food in the proportion of labor required for its production.

Even at the present time, all the available statistics prove that, measured in terms of money, the cost of food (including drink as one element, for whatever it is worth), is not less than three times the cost of clothing to the working people of this country and it bears even a greater proportion to the whole cost of living of the working people of Europe, probably four or five to one.

If this be so now, how much greater this disparity must have been twenty-five years since when the value of grain was exhausted by transportation over an area of one hundred and fifty miles on common highways, and when our railway service consisted only of a few disconnected lines inefficiently operated for a very limited service over a small area.

If, then, one-half the struggle for life measured in money, and more than one-half when measured by the work of the household of the prosperous mechanic, artisan, or operative; yet more than one-half, even in money, in respect to the common laborer, is the price paid for food, I think you will agree with me that the inventions and improvements of the last twenty years which have been, you will observe, mainly directed to the increased production and cheap distribution of grain and meat, have affected human welfare in even greater measure than those which ensued immediately after the invention of the steam-engine and the spinning-frame and more than any other inventions which have come into use in any single generation, or perhaps in any single century.

Limiting our present treatment to our own country, let it be observed that the one provision of our constitution which binds

these states most firmly into one nation is that which forbids any interference with free commerce among the states.

Under this provision, competition is now absolutely free over a larger area and among a greater number of people than are permitted this privilege in any other part of the world.

Suppose this provision of the constitution had not existed and that the people of the state of New York had endeavored to obstruct the purchase and use of the wheat of the far west, who would have suffered?

But although exposed to this free competition, the wheat production of New York is now almost as large as when Genesee county was the centre of the wheat production of the country, and to it has been added the great variety of profitable crops which make wheat but an insignificant factor in the whole agricultural product of the state of New York.

In making this statement, that competition is free over a larger area and among a greater number of people than anywhere else, I do not forget the existence of prohibitory liquor laws, or of laws in some of the states which restrict the liberty of adults in making contracts for the hours of their labor. The effect of such laws constitutes so slight an exception to the competition which is otherwise free, that they may be entirely ignored; neither would it be worth while to complicate the subject now under consideration by a discussion of the tariff question. It may be admitted that free competition has not existed between this and other countries, but this fact may be treated as an incident rather than as a prime factor in our progress: for the reason that owing to our great diversity of soil, climate and other conditions, substantially every branch of mechanical and manufacturing industry either had been established or would have been so, sooner or later, whatever our fiscal policy might have been. It is seldom observed that there are a natural diversity and balance of occupations in every civilized country, and the effect of tariff is rather to change the direction of a small part of the work done, than to alter materially the relative proportions. This has been especially true in this country where even the productions of iron and steel and the manufacture of woollen and flax antedated the birth of the nation itself and could not be suppressed even by all the power which the mother country exerted over the colonies.

In this area and among the people of this country, may be found as great diversities of climate, soil, condition, method of taxation (and even in systems of law, bearing Louisiana in mind) as are to be found existing between the people of different states or nations, hence a necessary diversity of occupations.

If we may judge institutions and customs by their fruits, this dominating spirit of liberty, of individualism and of free competition, has been most fully justified in its results. I may here refer to a subject which I have elsewhere treated at some length, to wit: that in this principle of competition we have the most effective mode of coöperation among men, and that its ultimate beneficent result will be to remove all poverty which is not due to mental or physical incapacity. Time does not suffice to develop this branch of the subject in this address.

Imperfect, inadequate and insufficient as our system of common education may be, and subject as we have been to the incoming in enormous numbers of the illiterate or uninstructed of other lands, yet the people of these states possess on the whole that kind of education in greatest measure, whether attained in the schools or outside of them, which enables them to grasp the opportunities placed at their disposal by the advancement of science and by the progress of invention, and to apply them in the most productive way.

We may be very much dissatisfied with existing conditions. Life is altogether too narrow to the great mass of our people. Discontent, as well as necessity, is the mother of invention and the incentive to progress, but we may yet claim that nowhere else can such conditions of material prosperity be found as are even now to be found in this country, however dissatisfied and wholesomely discontented we may be.

Nowhere else are the products of labor and of capital so adequate and so ample.

Nowhere else are wages and profits so high.

Nowhere else is the cost of all production when measured in terms of labor so low.

Nowhere else are high wages, either in money or what money will buy, so sure to be the consequent result and reward of a low cost of labor.

Nowhere else, high as our taxes are, is so much general benefit gained from the expenditure of the taxes.

Nowhere else is so small a proportion of the public income wasted for destructive purposes, in the support of standing armies and navies, and in the passive war which is now reducing Europe to pauperism in almost every part of that continent.

As I have said, even our civil war itself, and the heavy taxes which have been imposed since it ended, have but little retarded our material progress.

There was not a single year during the war itself, in which the production of the northern states did not increase in quantity and in value, in a measure greater than the expenditure for the war in that year, and could any equitable system of taxation have been invented and applied quickly enough, the whole cost of the war might have been defrayed during its very progress; and yet the free states and territories would have come out with a larger capital, and a greater power and measure of production at the end than at the beginning, while the south would have been redeemed from poverty by the destruction of its fictitious wealth.

Not only may these propositions be maintained but it has lately fallen to me to prove (see Distribution of Products, G. P. Putnam & Sons) what Mr. Robert Giffin has also lately proved to have been the course of events in Europe: namely, that during the last fifty years, in the latter part of which the greatest relative progress has been made in the application of science to the useful arts, those whom we miscall the poor because they may as yet have accumulated no substantial amount of property, have yet annually obtained an increasing share of an increasing product, while the proportion of the annual product secured by the rich as a separate class, has steadily become a decreasing proportion. Yet such has been the rapid increase of product year by year that while the poor have thus become more prosperous the rich have become no poorer and are more numerous. There have been temporary fluctuations but in each decade such has been the conclusion; even the present period of alleged depression is one in which the greatest relative progress is being made and when the adjustment is completed to the new conditions arising from the more recent applications of science which I shall presently consider, I venture to predict that it will become evident to the most superficial observer that such is the fact.

These are perhaps startling propositions and they may be questioned.

Let us glance at the list of almost new forces which were perfected, extended or applied during the war, or which have been put to use since the war ended, both in this country and elsewhere.

Afterward we will consider the newly available areas of productive land which have been put to use in this and other countries during the same period, from which we now derive a part of our own abundance in exchange for the excess of our domestic products.

But before we consider these new forces, a few words need to be given to certain changes which occurred in the decade immediately preceding the war.

In ten years prior to 1860–61 California and Australia had suddenly rendered up their great stores of the precious metals, as if in anticipation of the needs of the great commerce which other discoveries and new inventions were so soon to bring into existence.

It is often, but I think mistakenly, supposed that there is a productive force or influence in gold and silver themselves, and that a great addition to the money metals of the world constitutes a great addition to the productive powers of the world. I question this view; these metals are but instruments of distribution.

Had not the vast additions of the precious metals been accompanied or immediately followed by the application of these other forces, which I shall presently name, and which made greater production and wider exchange of products possible, the only effect of the addition of such a vast fund to the money metal of the world would have been a great advance in the prices of commodities; and during such a period the rich would have become richer, while the poor would have become poorer; for the reason that any inflation of the currency, whether on a paper basis, or on a specie basis which is effected suddenly, raises prices much faster than wages follow. Witness the effect of the great mass of gold which was suddenly placed at the dispcsal of Germany by the payment of the French indemnity. It may be questioned whether the disasters which ensued from this sudden accretion of wealth in Germany were not greater than the burden imposed upon France. It precipitated the one country into disastrous speculation, while the other went quietly to work to replace the devastation of war.

It is only the stimulus that rising prices have in making

employment continuous, which renders them any benefit to those who work for wages.

The exchange of this vast increase of our products, which immediately followed the addition of our stock of money metal after 1850–60, might have been hampered and crippled for want of instruments of exchange, except for the discovery of gold; but to impute abundance of other products to this discovery, as a cause of the increase, might be like imputing the abundance of petroleum with which the world is now lighted, to the scarcity of whales. Many other analogies could be found.

In connection with the production of the precious metals the wonderful inventions in hydraulic mining may be named, which belong to the period now under consideration, in the application of which it has become profitable to wash a ton of gravel for ten cents' worth of gold.

Prior to 1865 the railway mileage of this country was less than 34,000, consisting in great measure of detached lines, many of them serving for merely local purposes. Even the consolidation of a through line from New York to Chicago did not take place until 1869. Now our railway mileage is over one hundred and twenty-five thousand miles, consolidated in great systems and worked with an efficiency and economy unknown in any other country. One-half of the traffic over these railways consists of food for man or beast. The grain crop of 1865 measured 1,127,499,187 bushels; of 1884, 2,981,920,332. That of 1885 will probably exceed 3,000,000,000, over 50 bushels per capita.

What would have become of this food had it been raised while the limit of transportation by wagon was limited within an area of one hundred and fifty miles? Would it not have rotted upon the field had it been produced?

It was the Bessemer method of making steel which rendered this transportation of food possible over the longest distance at the lowest cost.

The man who now gives up one holiday in each year, and devotes it to earning wages, removes the obstruction of a thousand miles of distance in obtaining his year's supply of food. One holiday in the year devoted to work puts the mechanic of Massachusetts next door to the prairie of the west.

New inventions in the manufacture of steel even now in progress of application in this and other countries, may, presently,

do away with the necessity of moving the ores of iron over long distances by rendering the presence of what have been impurities in the ore of little consequence; thereby bringing into immediate use vast deposits of iron ore in the very heart of our own country which have until now been of little use and almost of no value. And when we adopt these processes we may then convert iron ore into food for man and beast, as they now do in Germany, where the waste of the "*basic*" process of making steel is now treated for the recovery of phosphate of lime which is left in the slag, to be converted into a fertilizer.

Is it not a startling thought that modern science has converted iron stone into food?

In the period under consideration the screw propeller has finally displaced the paddle-wheel in all ocean traffic. At the same time the compound steam engine has been perfected; the end of both being that the fuel required has been vastly reduced, and where it required over 200 tons per day of coal to cross the Atlantic twenty years since, a much more capacious steamer is now driven across by the use of 35 tons. But this statement is far from showing the full change; the important matter is the ratio of the fuel to the weight moved; every pound of coal now carries thirty-two times as much cargo across the Atlantic as could be carried thereby in the earlier days of ocean navigation. The steamer "Persia," in 1850, consumed 14,500 lbs. of coal to each ton of cargo, while even the racer "Arizona," in 1882, consumed only 450 lbs. per ton of cargo. In the freight steamers, assuming paper to have the same calorific value as coal, the combustion of an ordinary letter, such as is carried by mail for a two-cent stamp, would move a ton of cargo and its share of the vessel two miles. A lump of coal which can be mailed anywhere in the Postal Union for one cent would do the same work. Thus has room been made for cargoes of provisions or other merchandise, now carried at low cost more than half way round the world, to feed and clothe the people of the most distant lands.

The Suez Canal has restored commerce to its old lines, but by more speedy and cheaper methods. The general adoption of the telegraph renders distribution quick and equal, and these two forces have done away with the necessity of accumulating and storing great stocks of merchandise at heavy cost, and in other ways have vastly reduced the cost of distribution.

Agricultural machinery has been perfected in this same period to the end that the equivalent of one man's labor for one year, in the direction of this machinery, is wheat enough to give a thousand people all the bread they customarily use during the same twelve months, while corresponding inventions, too numerous even to mention separately, have reduced the labor cost of producing corn, oats, and of making hay in almost equal measure. One man's work for one day will pay for moving a year's supply of grain and meat a thousand miles and one man's work for one year on the far-away plains of Dakota will yield wheat for a thousand people for the same time.

Not only have our own prairies and those of Canada been brought to the use of man by these inventions and the application of these new forces, but the vast plains of Australia, New Zealand and the middle sections of South America, upon the Paraguay and Parana rivers, now send their grain or their dry or frozen meat to the hungry men of Europe, and yield up the abundance of their wool to all who are wise enough not to obstruct its use. Except for the railway and steamship their products would have been almost without value.

Within this period the whole process of canning meat, fish, fruit and vegetables has been developed, the refrigerator car and steamship compartment have been constructed, cold storage houses and ripening houses have been invented:—in the latter the banana, one of the cheapest and most abundant of the tropical products, which was first introduced into the temperate zone as a luxury, may be ripened in such abundance and at so low a cost that it may yet become an important article of food, being very rich in nitrogen.

The oil wells of this country and Russia have given light to those who could never before extend their day's work beyond what the sunshine permitted. The invention of the pipe lines for distribution has enabled that product to be distributed. In this connection may be mentioned the extraction of colors; or, as my friend Dr. T. Sterry Hunt stated it, when I asked him to add to my list any other suggestion of important inventions, "the creation of new coloring materials from hydro-carbons, chiefly from the refuse of coal distillation, which have already made a revolution in dyeing and printing. Yet more important, perhaps, as suggestive of what may follow, we may name the artificial production of

alizarine (the red of madder) and of indigo both of which substances are now manufactured on a large scale, while the madder culture has been almost abandoned on account of the greater cheapness and the advantage in the use of the artificial substitute. This abandonment of madder culture is not a loss, but a gain: because it frees large areas of land in some parts of Europe which are needed for the cultivation of grain."

Not least among the advantages which have ensued from the distillation of petroleum, has been the substitution of the lubricants made therefrom in place of animal or vegetable oils; the latter, being subject to rapid oxidation commonly called spontaneous combustion, were constant sources of danger in the factories where they were once used, while the mineral lubricants now in use, are absolutely free from this danger.

When we bear in mind this fact, that important products like indigo and alizarine have been derived from these mineral sources, is it visionary to suggest that a time may come when the *hydrocarbons* may be converted into the *carbo-hydrates* of which we hear so much in the chemistry of food? After we have converted iron-stone into food by way of the laboratory of the soil, and since we have generated colors and perfumes from coal tar, may we ever expect to convert the hydro-carbon of petroleum into the carbo-hydrate of the physiologist in the laboratory of the chemist? Another revolution has occurred in the production of soda by the ammonia process, replacing the old method and dispensing with the use of sulphur. We all know that the march of civilization may be measured by the demand for soda ash and other alkalies.

In connection with this may be named the processes by which all the volatile products of the coke ovens are now saved, and a vast product of oils and of ammonia is thus obtained.

In medicine the artificial product of the alkaloids such as morphine and quinine may be mentioned as among the possibilities of the near future. To these may be added the great discoveries which have been made during the last few years in the use of antiseptics, especially in connection with the preservation of fruits, wine, beer, etc.

Electricity has been put under control as yet mainly for light, but who can tell how soon the electric current will be divided or when this old but ever new force may be placed in every house-

hold, to be applied even more readily than the force generated by the combustion of coal.

Among the lesser of the new mechanical forces which have been applied during this period, we may name the substitution of the roller for the mill-stone in the preparation of flour, while the wheat elevator for the storage of grains has been perfected.

The driven well, which may hereafter make many a desert blossom like the rose.

The application of the diamond drill, worked by steam or compressed air to the boring of these wells, and also to mining.

The use of nitro-glycerine, or other high explosives in mining.

The application of steam or hydraulic power to the derrick or the crane for handling heavy weights, and for loading and unloading vessels.

The introduction of the elevator, lift or vertical railway into hotels, office buildings and warehouses, whereby the aggregate rent of land has been reduced, although the special rent of particular places may have been increased.

Not least among the developments of this period has been the great perfection to which machine tools have been brought, accompanied or rendered possible by the adoption of standard measures and gauges, to the end that the interchangeable system has been applied to almost every kind of mechanism from the locomotive engine and the sewing machine to the finest watch. The sewing machine has become the common implement of the housewife, the seamstress, the shoemaker and the sailmaker.

A woman may pass through the office of a Lynn boot and shoe factory to inspect the work who, being measured as she passes the office, will find a pair of boots perfectly fitted to her foot, finished and ready for her use as she goes out, after having looked over the five floors of the factory. The boots will have passed from machine to machine much faster than she can comprehend the process of the work even in the most superficial way.

Every one of you will add something to this list, each important in its place. And to these absolutely new applications of science may be added improvements in the construction of old machines previously invented, especially in the textile arts, by means of which the product has been increased and the requisite number of laborers has been reduced in greater measure than in any pre-

vious period since the substitution of automatic machinery for the spinning wheel and the hand loom.

In the cutting and preparation of timber and its conversion into boards, I have been told that a few simple inventions have rendered the work of one man as effective as that of sixteen men twenty years ago. A little stream of cold water distributed from the hollow axle of the circular saw, to keep the saw cool, has rendered it possible to substitute six foot circular saws and a steam feed for four foot saws or less, fed slowly by hand. The planing machine invented a little earlier has come into practical use together with innumerable other inventions in wood working.

The application of iron and steel to purposes of construction has made vast progress, of which the elevated railway in New York is a conspicuous example. The common use of structural steel may also be named and the development of the cantilever principle in bridge construction.

But iron is less useful, less safe and more costly than timber and brick, even at the present prices, for the construction of mills, works and warehouses; and in these branches of construction very great progress has been made in the combination of brick and timber. By the adoption of suitable methods the modern American factory has become one of the safest fire risks in the world, costing less for its insurance than the so-called fire-proof factory of Great Britain.

This safety from loss by fire has been accomplished, in part, by what is known as the open timber construction, free from cellular or concealed spaces, the timber being in some dangerous places protected by plastering laid on wire lathing; and in part by the adoption of the system of automatic sprinkling, whereby the fire lets on its own water, puts itself out and tells where it is at the same moment.

Another great step in the progress of the art of building factories and works consists in reducing the number of stories as nearly to one as circumstances will permit. The use of a three-inch solid deck made of timber, for a roof, making the one-story factory cool in summer, warm in winter, while such a one-story factory may be better lighted and ventilated, and is more suitable for general use than any other form.

In this connection reference may be made to some of the possibilities of the future.

The adoption of steam power and the use of coal gas for lighting have rendered a great concentration of the manufacturing and mechanical arts an absolute necessity; this concentration of the work in closely built towns and cities has of necessity been followed by a concentration of population under adverse conditions, both with respect to health, economy of rent and other matters.

Whenever the electric current can be divided economically, so that a measured amount of power or light may be sent over wires in different directions from the same source, water power may be utilized where dams can be built with the greatest economy, but which are now useless for want of proper space for the construction of factories near them.

Large steam engines working at $1\frac{4}{10}$ lbs. of coal per horse power per hour, or less, may be substituted for small steam engines requiring from four to eight lbs. Gas for heating purposes may soon be as widely distributed as it now is for illuminating.

Under such conditions, power and light being furnished in the same manner, the directions for the work given by the telephone from the city office, factories which now occupy dangerous and unsuitable positions in the fourth, fifth and sixth stories of our city warehouses, may be scattered over a wide area in the suburbs of the same cities, in well ventilated and cheaply constructed one and two story factories, surrounded by dwelling places, each with its small plot of land, where the working people can live under vastly better conditions than they can now live in the narrow courts and streets of the cities.

Less conspicuous but even more important than almost any discovery or invention yet named in their ultimate effect upon our food supply may be recited the opening of the Stassfurt potash mines in Germany, and the discovery and working of the phosphate beds of the United States and quite recently those of Canada.

In the latter, deposits, which are 80 per cent phosphate of lime, have been found in almost inexhaustible quantity, and under such conditions that they will be very cheaply furnished to all our western and northern states and territories.

Mention may also be made of the mines of very pure salt on the Canada side of Lake Superior which may presently yield, if they do not already, the necessary supply of salt most suitable for the preservation of meat; these mines are also close to the prairies of

the West and subject to our use whenever we are wise enough to remove the obstructions which now render the import of salt more costly than it need to be.

These discoveries were prophetic. Who knows yet what may come from the alkali plains of the far west or from the volcanic region which lies between Oregon and California? None can doubt that there are mines yet to be opened in that section more precious than those of silver or gold, of which one example may be mentioned, consisting of vast deposits of sulphate of alumina lately discovered.

I may venture to add, among the most important applications of science to agriculture, the re-discovery of the system of preserving green crops in pits known as "ensilage."

There remains but one great discovery to be made to round out and complete this list which I have presented to you, and to perfect the series of the present generation.

Whoever can attract the nitrogen of the atmosphere, and combine it with the potash of Germany and the phosphates of South Carolina or Canada, will add the last element necessary to secure permanent abundance in agriculture at the least cost.

It is possible, I will even say probable, that the solution of this question may lie in the one plant, as I will presently attempt to show you, which might well be adopted on the coat of arms of this country, namely, Indian corn. Perhaps this symbol may be justified in the peaceful war which we have just waged with our foreign enemies.

Who were our enemies when we were engaged in a contest for liberty? Were they not the privileged classes of Europe, whose main-stay has been the rent of the land possessed, but not worked by themselves?

We have attacked them with shiploads of grain and meat. We have sustained the operatives of England who sacrificed even their daily bread in our cause, while we have rendered the collection of rent from land devoted to grain hereafter almost impossible in Great Britain, except it be earned by the owner himself who may put capital, brains and personal industry to the use of his own land.

Said I not rightly that greater progress has been made in the period which has elapsed since the beginning, or even since the end of our civil war, in the advancement of science and its appli-

cation to human welfare, than in any other previous generation in the history of the world?

Time will not suffice for me to more than refer to the substantial foundation and extension of technical education in the same period both in this and other countries; to the beginning of scientific methods of manual instruction; to the great development of statistical science; and to many other intellectual factors which have also marked the era of which we are treating.

But there is a reverse to this pleasant picture, and much more remains to be accomplished.

Vast progress has been made in individual wealth and in common welfare. The time necessary to be devoted to the struggle for life has been reduced; leisure has been earned and earned in such a way that it has not become license, but will become the opportunity for that moral and intellectual progress which must always be founded on material progress if they are to become general.

Great as our progress has been and huge as our abundance now appears to be, yet we cannot too often recall the fact that the average product to each person in this most prosperous country, measured in money at the point of final distribution for final consumption, does not exceed fifty to fifty-five cents worth per capita, and our whole accumulated wealth, aside from land, does not exceed two or at the utmost three years' production.

Let us not boast too much nor think that we can remit our work in the least degree, when we remember that after we have set aside only so much as is required to maintain or increase our capital, so that it shall bear a due proportion to its necessary use, and after we have provided for the support of the government by taxation, each average person must find shelter and be supplied with food and clothing, out of what forty to forty-five cents per day will buy, because such is the measure in money of all that is produced and we cannot have more than all there is. I have treated this matter at length in another place, but I ask you to recall this when you are considering the daily rations which are served at a cost, varying from fifteen to thirty cents per person and the table of economic rations which accompany this address.

When our resources are thus reduced to 40 or 45 cents per day, you are somewhat startled, but each person who is engaged in gainful occupation in this country sustains two others: at 40

cents a day the expenditure of three persons comes to $438.00 per year; at 45 cents to $492.75, which are not so startling figures, when compared to what we know to be the average earnings of working people.

What can be done for those whose income is less than forty cents a day for themselves and their children and who must spend more than one-half for food? They are counted by millions even in our fair land.

Whenever any great invention or discovery displaces common laborers whose education or development has never been of such a kind as to fit them for any other work than that to which they have been accustomed, they suffer for the time.

What can we do to aid those who have been almost crushed in the onward march of industry? When partly automatic machinery is substituted for manual labor in any given art, although the many consumers gain a greater supply at less cost and a few trained workmen obtain higher wages in guiding the machinery while doing the work at less cost than before; yet, those whose only occupation had been in this handicraft may lose even the pittance which they had gained before and they are apt to be the persons least capable of adjusting themselves to new conditions. Witness the suffering of the hand loom-weavers of England when the power loom was first used. Bad as their condition had been it became for a time yet more wretched.

It is manifestly impossible to make any special provision in advance to meet the adverse contingencies of new invention.

The only adequate remedy for the hardships which must ensue, when those who have been engaged in the common kinds of handicraft have even that resource taken from them, is to develop the general system of education in such a way that there shall be the least possible number of children brought up under conditions which would limit them to a single art, and that a very low grade of hand work.

The disadvantage which ensues from the very great subdivision of labor which has been introduced with modern scientific inventions, is, that in the conduct of this work versatility or "*gumption*," as it is commonly called, is not developed such as was the very marked characteristic of the Yankee of former times.

The country boy, who attended the common school three or six months in the year, and during the rest of the time was of neces-

sity a "Jack-at-all-trades," was thereby enabled to become master of any trade to which he might afterward choose to devote his time. Such is not the case in the present day.

A good beginning has, however, been made in the attention now given to manual instruction as well as mental, but the benefit of what we are now doing in this direction will only be realized in the future. Our problem is with the present.

Witness how suddenly changes may come which involve great hardships to those least capable of meeting them.

In the census of 1880, the fact was disclosed that out of every thousand persons who were occupied in all kinds of gainful occupation, mental, mechanical and manual, three hundred and twelve could only answer the enumerator's question with the reply that they were *common laborers*. Among these common laborers there were over eighteen hundred and fifty thousand, or more than ten per cent of all who were occupied in all the arts of life, who were engaged in common labor other than that upon farms. Where were they?

They had doubtless increased in number between 1880 and 1882 by immigration in very considerable measure and in 1882 common laborers numbered at least two millions; in that year not less than six hundred and fifty thousand persons, of whom at least six hundred thousand were common laborers, were engaged in the single work of constructing new lines of railway within the limits of the United States. This railway fever culminated in 1882 with the construction of lines numbering over 11,500 miles. In 1884 the construction was less than 4,000 miles.

Between these two dates more than four hundred thousand common laborers, or more than twenty per cent of the whole number of common laborers who were not occupied upon farms, were discharged and were compelled to find other work or to be idle. Where could they go? For what other work were they fitted? A part of the more intelligent and thrifty doubtless took up land upon the lines of the railway where they had been employed, but the greater part drifted back to the cities, where they gave the appearance of being much more numerous than they really were, because they were concentrated in particular places.

When this work ceased, the demand for iron also fell off a million tons, and consequently all iron works were affected, then the rolling mills. Then the demand which had existed for the supply of

the idle common laborers, of the idle iron workers, and of mechanics who had been engaged in this art of constructing new railroads, in part ceased, and the goods and wares which they had consumed began to accumulate; presently the effect of this was felt throughout the whole body politic.

One of the penalties which we pay for the complexity of the work of modern art and manufacture, is, that when the most insignificant gear is thrown out of place, the whole machine is crippled. We are all interdependent and the calamity which falls on those who are apparently the least important classes in society has an adverse effect upon the progress of the whole, like that which a slight injury to the foot, or a pebble in the shoe of a strong man, may have on his power of locomotion.

As I have said, the true remedy can only consist in the development of versatility, of manual dexterity, and of capacity on the part of the poorest child in the community, to take advantage of the many opportunities which may be found waiting at all times for those who are capable of grasping them. We may, however, alleviate the present difficulty in some measure, by reducing the necessary cost of subsistence. Before we enter upon this part of my subject, permit me to observe that in this address, I have kept the fact in view that the political economist may only treat the physical sciences in their direct connection with material progress. In the list of the scientific inventions and applications which I have presented to you, I have made no reference to abstract science or to the higher branches of research.

May I venture to give a summary of the conclusions which we may draw from the facts which I have presented so far as this country is concerned.

With respect to the primary processes of production, the applications of science, crude as they yet are in respect to agriculture, have assured an excessive abundance in ratio to any possible increase of population during this present century. There is enough for all and to spare.

With respect to the primary processes of distribution by land and by water, the cost has been reduced to such a point that there is little margin left to work upon for further saving.

In the conversion of crude materials into finished forms ready for consumption the field for invention and improvements is still a broad one.

In wholesale traffic, there is no longer any great margin to be saved and even in the retail distribution of staple articles the smallest profits suffice.

In the distribution of perishable commodities, there is an enormous waste, and in the science of consumption almost no progress has been made. It is only within a very recent period that even the statistics have been gathered, while I believe the beginning of a true study of the chemistry of food and a true science of nutrition may be dated within the period under consideration.

I have presented to you the two aspects of the question:— on the one side, the prophecy of the future, replete with the comfort of an assured abundance; while the statistics of the past prove conclusively that those who perform the arduous work of creating this abundance are steadily but surely securing to themselves an increasing share of the increasing product, and this product will yet continue to increase as capital and labor are combined in more harmonious relations.

On the other side, the data have been given which show within what narrow limits the great masses of this most prosperous people must now exist; even though they secure to themselves for their own consumption more than ninety per cent of all that is annually produced.

The danger of our time is the constant resort to legislative remedies for evils which can only be removed by the development of the individual.

I have brought this great problem of subsistence to the unit of the individual, because we can comprehend it better when it is stated in terms of what 40 or 50 cents per day will buy for each person.

We can, perhaps, comprehend how hopeless the problem of ameliorating the condition of life would be, were it not for the advancement of science, when the fact is stated that in order to give each person of our present population five cents' worth more per day, we must produce and distribute one thousand million dollars' worth more than our present annual product. We may confirm this impression both of the minimum and maximum elements of the problem by the consideration that if we reduce our present population of over 57,000,000 to the equivalent of 50,000,000 adults, by counting two children under ten as one adult, and then assign to each of the 50,000,000, one egg every two days at the

price of one cent each, then the annual value of the product of hens' eggs would be equal to the annual product of gold and silver of all our mines.

In the presence of the facts which I have submitted to you, may we not also find evidence that the hypothetical deductions of the English political economists, who narrowed the field which Adam Smith had opened but had not exhausted, must give place to more humane inductions based upon solid historical and statistical foundations.

Were there no promise of material welfare being attained upon this earth by any possible population which can find standing room upon it, all expectation of moral and spiritual progress would of necessity be surrendered, and the only motto of the social scientist might well be, " Let us eat and drink for to-morrow we die."

I fear that I have occupied too much time in this introductory review; we will now take up the more practical part of our work.

In the various tables which will accompany this address, and in the material which has been so kindly furnished me by Prof. W. O. Atwater of Middletown, Conn., it is made apparent that there is a wide choice in the ration of food necessary to sustain an adult man or woman in full vigor and health.

Again recalling the fact that with respect to this lowest plane of common laborers, the mere price of food constitutes sixty per cent of the cost of living, even for those who are fully and continuously occupied, it will be very obvious that if we can show them how to maintain themselves in full vigor at a cost of thirty or forty per cent of their ordinary income, we shall have done good service.

In Professor Atwater's table representing the cost of protein, it appears that we if we buy protein in a sirloin of beef at twenty-five cents per pound we pay one dollar a pound for it; whereas if we seek for protein in oat meal or in corn meal, we pay twelve to fourteen cents per pound for it.

It is also proved by these chemical investigations in respect to the elements of food, that the Scotch have by a process of natural selection, adopted in their oat meal that kind of food which gives them the right proportions of nutrient material at the very lowest cost.

The people of New England have also come to a similar conclusion by a similar process: in their baked beans and pork, and in

their fried fish-balls composed of dried cod-fish and potato, even in their brown bread, are also to be found substantially the right proportions of nutrient at a very low cost. To a Yankee it would not be a very great hardship under the pressure of adverse conditions, to be obliged to substitute baked beans, fish-balls and brown bread in a more considerable measure for roast beef, than they are accustomed to do when in a condition of prosperity.

The weekly ration of the southern negro, which he chooses in preference to any other, to wit: a peck of meal and three and one-half pounds of bacon, is also one which contains the elements of vital force at an exceedingly low cost. There are probably no working people in the world so cheaply subsisted as the southern negroes, if consideration be given to the force contained in the food. The rice of the east may cost less in money, but it is deficient in some of the nutrients which are necessary to full vigor.

There are, therefore, many ways in which temporary poverty can be alleviated, but it is not altogether desirable either to advise or to attempt to promote such changes in the diet as might, under the pressure of necessity, make a considerable saving.

The people of this country can afford a more abundant diet than that enjoyed by any other country, and they will continue to enjoy it because even periods of adversity affect a relatively small number of persons however unintelligent they may be.

The same conditions affect this question as that of taxation. I suppose no economist of repute has failed to reach the conclusion, that a system of direct taxation will lead to the greatest economy in the public expenditure; or that when the taxes are collected indirectly in such a way as not to come to the immediate knowledge of the consumers who pay them, twenty-five per cent at least will be wasted; and yet I am of opinion that the people of this country would prefer to pay about twenty-five per cent in excess of the absolute need rather than to have a direct tax imposed upon them.

And so I think that the great majority will prefer to continue their present practice in respect to the use of food as long as it is a somewhat difficult matter to learn how to combine true economy with a generous diet.

Our main attention may, therefore, be given to cheapening the cost of meat, rather than reducing the consumption thereof, and

with a few pages upon this subject of a rather visionary sort, I shall close this address.

Having presented the importance of animal products in their relation to the daily rations of the people; having also presented data giving proof that a part of the ration of animal products might well be spared if it continues to be as costly as it now is, the next question which arises is: May not the cost of animal products be greatly reduced by the adoption of more scientific methods of production? Upon this subject I may present to you certain hypotheses in which, I think I may be sustained by Professor Atwater.

Let me begin by reminding you that iron ore is now being converted in part into animal food in Germany, and that we may perhaps look mainly to our mines and to our atmosphere for our vegetable and animal food rather than to any other source, if other sources fail. We may treat the soil as a laboratory when the soil itself fails or begins to fail as a mine. We may restore it with mineral elements from mines in which they are found in a concentrated form.

We have throughout the eastern and most densely populated section of the United States a vast area of land which is not now considered worth cultivation. Much of it has once been cultivated and has sustained an intelligent people, but when the possibility occurred for obtaining Indian corn from far distant points, the cultivation of much of this land ceased, because it was not needed for market gardens, and it did not appear to be well adapted to pasturage.

In the section of Massachusetts where I pass my summers, old fields are being covered with scrub oak, and old dwelling places are falling into decay, where by means of intelligent cultivation sixty bushels of shelled corn to the acre can be made, and it is only a question of cost whether or not such a crop shall be made. This cost again depends upon the price at which the land can be fertilized.

Now the chemists assure me that this soil contains iron, magnesia and chlorine in ample measure; that it can be furnished with potash at a very low cost from many sources, especially from the inexhaustible mines in Stassfurt, Germany; that it can be furnished with the phosphate of lime at very low cost from the phos-

phate deposits of South Carolina and of Ottawa, to which latter source reference has already been made. Along the whole New England coast are also scattered the fertilizer works which draw their supplies mainly from the sea.

But it has been assumed that unless some kind of a fertilizer could be added to these substances containing nitrogen in large quantities, the effort to raise corn upon this land would fail; yet now comes Professor Atwater who tells us that so far as his experiments and his coöperative work yet prove anything, it may be proved that the Indian corn plant is analogous to clover, to the southern cow-pea and to a few other plants, in being capable of deriving its nitrogen, somehow or other, from the nitrogen of the atmosphere or from some natural source, and that it needs no expensive nitrogenous fertilizer to be applied to the soil, provided the other elements already named are there. But while the corn has done so well with the phosphates and potash salts, it has given still larger and more satisfactory results where these and farm manures were used together. In the plan herein proposed, stable manure would be furnished in great abundance. Professor Atwater's statement is as follows:—

"The important fact is, that the corn plant has in these trials shown itself capable of bringing fair yields with small amounts of the less costly mineral fertilizers, even in the worn-out soils of the eastern states. With this help it has gathered its nitrogen from natural sources, and holds it readily to be fed out on the farm and returned in the form of manure for other crops. In other words, the experiments, thus far, imply that the corn has, some how or other, the power to gather a great deal of nitrogen from the soil or air, or both; that in this respect it comes nearer to the legumes than the cereals; that, in short, corn may be classed with the 'renovating' crops. If this is really so, and this can be settled only by continued experimenting, then our great cereal, instead of being simply a consumer of the fertility of our soils, may be used as an agent for their restoration."

If this is so, it is difficult to conceive of the importance of these facts.

As I have before said, life is but a conversion of forces, and this proposition may be sustained with regard to animal life, as well as with regard to human life.

How, then, shall we convert the forces of our mines and of the soil and air into animal food for the use of man, by working over this deserted soil of Massachusetts into a beef factory?

The way is very plain and simple—*if*. (I call you to witness that I italicize the *if*.) Witness Farrish Furman of Georgia, after carefully studying the chemical elements of the cotton plant, invented a fertilizer, at very low cost, by which he brought waste and deserted cotton land, from $\frac{1}{8}$ of a bale to $2\frac{1}{2}$ bales to the acre. In so doing he made use of the Stassfurt potash and the phosphate rocks of South Carolina. By way of his laboratory, consisting of wasted soil which had long since ceased to be a mine yielding cotton, he converted the two minerals named into cotton seed. We may buy the meal of this cotton seed, bring it to Massachusetts, there feed it and thus convert the same minerals into fertilizing elements, in the soil laboratory of Bristol or Plymouth counties.

Here we have not only the phosphate and the potash, but also a food for beasts very rich in protein, yielding the most valuable manure by the use of which we may enable our laboratory to grow Indian corn at the rate of 20 to 25 and some claim even 30 tons of forage to the acre.

Suppose we put this forage into pits and feed it at the rate of two steers to an acre, adding each year the ration of cotton seed meal to the sixty pounds of ensilage daily required by a steer. We may also soon find some other very nitrogenous plant capable of being grown in the north, which like the southern "cow-pea" will produce a very heavy crop of forage on very poor soil. Cow-pea vines, being mixed with Indian corn in ensilage pits, appear to yield the necessary proportion of protein, so that, in North Carolina, working mules are now sustained upon this mixed ration of pitted fodder in as good condition as when previously fed on northern hay.

What may be the result of our conversion?

I am assured that if we slaughter the steer, removing all the salable products, the hide, the meat, the bone and the hoof, we should yet remove less phosphate of lime and less potash than we had fed through the steer to the soil. Our Indian corn might somehow have entrapped the nitrogen of the atmosphere, and with the fertilizing elements of the cotton seed, would again have enriched the soil; our soil laboratory would thus grow more productive every year in ratio to the number of animals which we fed upon it, per-

haps until we fed possibly three steers to an acre. This has never been done within my knowledge, but I do not believe it is beyond the power of science to make such a crop upon a fair acre of land in a good season, as to yield sufficient forage to carry three steers to an acre if not for a full year, then for at least eight months in a year, and during the remainder of a year they could as well as not be turned out to the wild land in the neighborhood for pasturage. There is room enough in New England on land now going to waste to raise all the beef we can eat, and more, if such methods are feasible.

Without giving any especial attention to the matter I have myself been keeping two cows on the crop of a single acre for nearly a year, year by year since 1880, but I am rather ashamed to say that I cannot give the measure of meal or middlings. I have only proved to my own satisfaction that it is easily possible to raise as much corn fodder on an acre as two cows require for one year.

What would be the cost of beef in money? Would it not be the price of the cotton seed meal and the price of the labor? to which may be added, if any one chooses, a slight additional sum for the interest on very low priced land. I do not put interest on the capital invested into the cost of the product, because that is what the capitalist would work for; that would be his profit.

Again, if deserted land can be used in this way in the eastern part of the country, what would be the method of use?

I have referred to the land as a laboratory and to the establishment as a beef factory, and I did this with a purpose.

A small area of land can be kept under the intelligent supervision of one man (either the owner or his superintendent who may himself do no part of the actual work); then the land worked as a laboratory would be like the factory in its administration.

Furthermore, every part of the planting, cultivating, harvesting and feeding can be done by the piece, paid for by the measure, and supervised with as much accuracy as the working of the cotton factory can be supervised by an agent.

The subdivision of labor can be made in the same way; each workman in the beef factory, having his work assigned to him by measure, can be paid by the piece or job, precisely as the work of the cotton factory is subdivided. The end of such a method is the largest product at the least cost.

If the hypothesis, which is not yet absolutely proven, but in favor of which the array of facts is so strong as to leave Professor Atwater in but little doubt about it, be hereafter sustained that Indian corn has the power of gathering its nitrogen from natural sources, then it may be safely affirmed that a three-year old steer can be produced upon the waste land of New England at this time at less cost than the same steer can be produced from Texas by way of the western plains to the Brighton abattoir on the basis of the present charge for Texas cattle on their native plains.

Here, then, we may be able to reduce the cost of meat if the alternative of using less meat is not acceptable.

But, even if this solution may not prove to be the true and final one, may we not expect to displace the semi-barbarous or wild system of raising steers on our far-distant plains—moving them in cruel cattle cars at heavy cost and thus providing meat which is very liable to be unwholesome — by substituting methods more consistent with science? When we can do so we may be able to advise our young men in New England to *stay east* rather than to *go west*, and thus maintain a better and safer balance in our population, of which in Massachusetts more than one-fourth part is now foreign born.

If these points are well taken; if it is possible to treat the soil as a laboratory without very much regard to its original properties, or, at least, without so much regard to the original properties as is commonly given, a great change must be made in the postulates of economic science.

When the intensive system of farming is adopted, tending to a greater concentration of the population engaged in agriculture, which change may be accompanied, as I have endeavored to show, by a wider diffusion of the population now too much concentrated in cities, the whole balance of the population will be changed; both the agricultural and the manufacturing population will be brought nearer together, and all will be brought under vastly better conditions of society than either class can now enjoy. Furthermore, several of the *a priori* concepts of the English economists must yield.

The law of diminishing returns from land can neither be sustained historically, theoretically nor practically.

The so-called law of population, that population tends to increase faster than the means of subsistence, has no foundation

historically, practically nor theoretically if the propositions which are presented in this address have any validity.

The Ricardian theory of rent will have no basis whatever.

What may be the future of humanity under these conditions no man can tell.

What may be the influence of this country upon the rest of the world no man can foresee.

In order that you may, in some very dim manner, foreshadow this influence, I beg to submit to you a few statements in figures and in black lines which I have made use of in another publication.

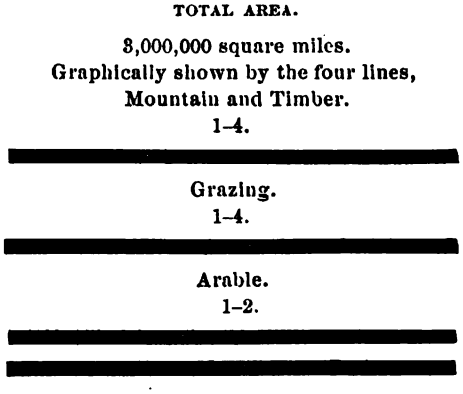
I present to you lines indicating the total area of the United States accompanied by others which show the little fraction of our soil, which has yet been devoted to the production of grain and cotton. Even this little fraction is double what would be required under an intelligent and intensive system of agriculture.

To these lines, showing what has been done, I have added other lines, showing what may be done in the production of wool, of meat and of dairy products, and these again are measured upon an assigned product to each acre of only one-half that which has been actually accomplished in certain places.

In this table, I have dealt in a rough and ready way, with the acres now occupied or which might serve for all our great crops.

The area of the United States, omitting Alaska, is a trifle less than 3,000,000 square miles.

In a broad and general way we may assume that one-half this area is good arable land, one quarter good pasture land, and one quarter forest, mountain, and mining territory.



INDIAN CORN FIELD.

112,500 square miles.

At 25 bushels to an acre this area produces 1,800,000,000 bushels. This corn is largely converted into pork at the rate of 5 lbs. of corn to one pound of pork. Assuming one thousand million bushels thus converted, and the rest used for human or cattle food, the product of pork would be equal to 18,500,000 casks or its equivalent in bacon; which would give nearly one cask of pork of 300 lbs. to each head of a group of three persons per year, or 100 lbs. per capita.

WHEAT FIELD.

60,000 square miles.

At 13 bushels per acre this little area yields a little over 500,000,000 bushels. Setting aside an ample portion for seed this quantity would give over 80,000,000 persons one barrel of flour per year.

COTTON FIELD.

20,000 square miles.

At the wretched average of only half a bale to an acre this little patch yields 6,400,000 bales in a year.

WOOL.

What the actual area of sheep pasturage is no man can tell, because the area of land absolutely free to graziers and ranchers is so large that no question of area has arisen until within a very short time; but the end of this wasteful and archaic method can be foreseen. When the cur-dog shall have been muzzled, or when dogs shall have been declared *ferœ naturœ*, it will be easily possible to sustain four sheep to an acre over wide areas of unoccupied land in the east and south as well as in the far west; this would require a sheepfold of

40,000 sq. miles,

sustaining 102,400,000 sheep, which at only 4 lbs. each would yield as much wool as we now consume of all kinds, both domestic and foreign.

DAIRY FARMS AND HEN YARDS.

In 1880 the number of milch cows was estimated at 12,500,000, and the product of eggs was computed at 500,000,000 dozen,

valued at $80,000,000. Over how wide a range of pasturage the milch cow ranged it is impossible to say, but almost within the period which has elapsed since 1880 it has been proved entirely possible to feed two cows one year on the corn-stalks saved in pits which can be raised on one acre of fairly good land, if to this green fodder be added a ration of meal made from the cotton seed which was almost all wasted until a very recent time, and is yet saved in only a very small proportion. But in order to be safe we may reverse this ratio, and assigning only one cow to two acres we may greatly increase our present ration of milk, butter and cheese, with the hens' eggs thrown in.

A Dairy Farm and Hen Yard
of 60,000 square miles,

at 1 cow to 2 acres, will sustain 19,200,000 cows. I have myself no difficulty in keeping two cows one year on the forage of one acre with a moderate feed of meal, or wheat middlings added.

BEEF.

The relative importance of meat in the subsistence of our people has been shown. A large portion of our beef is now produced by almost semi-barbarous methods on the far-distant plains; but as population increases this rude way must give place to more civilized and humane modes, and our beef must be produced near its place of consumption. Provision has been made for the cornfield, and if pitted forage is as fully justified on a broad scale as it has been in the successful experiments of many able men who have applied brains and capital to the use of land, it would be necessary to assign only a small area to beef.

60,000 square miles,

at 500 lbs. of meat to an acre, would yield nearly one pound of beef per day to our present population (reckoning two children as one adult).

If these propositions can be sustained, it follows that our present crops of corn, wheat and cotton, and a very much increased product of the dairy and poultry-yard, as well as of meat and wool, can be raised on

352,500 square miles,

or upon twelve per cent of the total area; and even this assign-

ment of land is nearly double what might be required if the *intensive* system of farming were adopted by men of sufficient intelligence and capital to conduct all parts of the work in a reasonably good way.

It is held that in the face of this demonstration the charge that poverty is now to be attributed to monopoly of land in this country is utterly disproved, and that the explanation of extreme poverty must be sought in other directions. It is painfully apparent that extreme poverty is to be found chiefly among those who are foreign born, but there is as much free land open to them as there is to the native born, —enough and to spare for both.

If these propositions can be sustained, it may therefore happen that when the population of the United States of 1880 shall have doubled,— perhaps in the first decade of the next century,— an area of land no larger than that which is assigned in these graphical lines will be required to sustain the people of that day; it may happen that the hundred million people then existing upon our national domain will require a very much less area of soil to sustain them than is now devoted to the subsistence of the present population.

Venture then to imagine one hundred million English-speaking people living in comfort and welfare upon our national domain, even then making use for the necessary purposes of subsistence, of only one acre in eight or ten of our whole area; free from national debt, paying their national taxes under a well devised and intelligent system, meeting their competitors in the commerce of the world with vast quantities of every kind of produce, and of manufactured articles which will have been produced by the application of the best machinery to the greatest natural resources to be found in any similar area of the earth's surface. The working people who will then, as they do now, constitute more than ninety in every hundred of the population, gaining a constantly increasing share of an increasing product with less effort or labor in each decade, as the decades pass.

Can the standing armies of Europe be sustained when the full economic effect and the moral influence of this nation is thus exerted?

The material subjects which we treat are but one phase of that life of which the moral and the spiritual are also integral parts,— each resting upon the other, each more or less dependent upon the other.

Even among the figures and the dry statements of facts with which we are called upon to deal in Section I, may we not therefore find something to arouse the imagination and much to stimulate the higher life which is the end of all our work?

Of a truth the swords shall be beaten into ploughshares and the spears into pruning hooks.

In our far southern land, upon the heights around Chattanooga, were many ramparts within and before which thousands rendered up their lives in order that liberty might be established over all our domain.

Even from death unto life sprang forth the new industry of the new south; those very ramparts are now the walls of the reservoirs which supply the free men of that city with living water.

So may it be in all lands when men learn to serve each other in beneficent commerce and when all the nations of the earth shall have become interdependent.

STATISTICAL TABLES.

If the basis of the consumption of adult factory operatives, composing a large proportion of females and the lesser proportion of men customarily occupied in or about a cotton factory in the eastern or middle states combined, be adopted as a fair standard for the average per capita consumption of the country, the consumption statement of the present population of 57,000,000 as the equivalent of 50,000,000 adults by computing two children under ten as one adult, would be as follows; the data being compiled from a sufficient number of records between 1880 and 1884, to be reasonably accurate; since the computation prices have fallen considerably. The proportion of tea, coffee and sugar is probably somewhat above the average consumption, women apparently consuming a larger proportion than men.

	CENTS	CONSUMPTION OF THE U. S. ON THIS BASIS.
Meat, poultry and fish, per day ½ to 1 lb.	9.70	$1,765,000,000
Milk ½ pint, butter 1½ to 1½ oz., cheese, a scrap,	5.00	912,500,000
Eggs, 1 every two days at 12 cents per doz.,	.50	91,250,000
	15.20	$2,768,750,000

	CENTS		CONSUMPTION OF THE U. S. ON THIS BASIS.
Amount brought forward	15.20		2,768,750,000
Cereals,	2.50		456,000,000
Vegetables,	1.98		360,500,000
Sugar or syrup,	1.94		353,000,000
Tea or coffee,	1.20		185,000,000
Fruit, green or dry,	.62		113,000,000
Salt, spice, ice, etc.	.49		89,000,000
Total per day,	23.93	per year,	$4,325,250,000

The estimates of the cost of drink range from a mimimum which has been established by Mr. David A. Wells after careful research of $474,823,000, to various sums reaching very extravagant figures. It may be fairly computed that the total price of food to consumers is over $5,000,000,000; the price of clothing, carpets and other textile fabrics which are directly used by men and women may be fairly computed at $1,500,000,000.

Dietary No. 2.

Fourteen adult men and women in Massachusetts, nine men engaged in mechanical work, three women in mill work, two in the care of the house, for six months in 1885. (Mostly Irish.)

	CENTS
Meat per day,	9.52
Milk, butter and cheese,	6.50
Eggs,	1.40
Total animal food,	17.42
Cereals,	4.07
Sugar and syrup,	1.90
Vegetables,	1.32
Fruit, green and dry,	1.17
Tea and coffee,	.70
Sundries,	2.14
Total cents per day,	28.73

Dietary No. 3.

A French Canadian family of ten persons, four adults, six children, two to eighteen years computed at 4½ adults. Total 8½ adults. Massachusetts six months in 1885.

	CENTS
Meat and fish per day,	5.02
Milk, butter and cheese,	4.63
Eggs,	.96
Total animal food,	10.61
Cereals,	3.00
Vegetables,	2.82
Sugar and syrup,	1.87
Fruit, green and dry,	1.05
Tea and coffee,	.63
Sundries,	1.81
Total cents per day,	21.79

Dietary No. 4.

A well-to-do American family, father and two sons, mechanics, three adults, five children, two under ten years old. Massachusetts, six months in 1885.

Meat and fish per day,	9.70
Milk, butter and cheese,	6.73
Eggs,	1.43
Total animal food,	17.86
Cereals,	3.83
Vegetables,	3.21
Fruit,	3.28
Sugar and syrup,	1.88
Tea and coffee,	1.25
Sundries,	2.53
Total cents per day,	33.90

Dietary No. 5.

I am indebted to Mr. J. S. Lord, Chief of the Bureau of Statistics of Illinois, for the most comprehensive statement of the cost of the food of a large number of persons, which I have ever seen, except in the data of armies.

It was prepared by Dr. Fred. H. Wines, Secretary of the Board of Public Charities of Ill., from the accounts of the Public Insane Asylums, Institutions for the Blind, Deaf and Dumb and

Feebleminded and of the State Reform School. This report covers the cost per day of sustaining these institutions for ten years, lacking two months, from Dec. 1, 1874, to Sept. 30, 1884.

The average number of persons fed was 3,293: inmates 2,779, officers and employés 514. The total number of days' board was 11,828,685: inmates 9,981,483, officers and employés 1,847,202.

No account has been kept and no estimate has been officially made of the garden stuff raised on the farms connected with these institutions, nor of milk, nor of pigs and poultry raised and eaten. The statistics cover only the food purchased. The dietary is as follows:

	CENTS
Meat, fish, butter, lard and eggs, per day,	6.69
Cereals,	2.34
Vegetables,	.53
Sugar and syrup,	1.22
Tea and coffee,	.62
Sundries,	2.09
Total cents per day,	13.49

All purchased at wholesale prices. Dr. Wines estimates the consumption of milk at one-tenth of a gallon per day which at 20 cents a gallon would add two cents per day. He also computes the value of the farm products raised on the farms connected with the institutions at two cents per day each person, which being added to the money paid for provisions would bring the actual ration to about 17 cents per day per person, which is somewhat above the cost of food provided for the prisoners in Massachusetts jails; but due regard being given to the members of skilled officials and employés, to the greater variety of food and to the abundance of vegetables raised, the ration may be considered one of a higher grade.

The inmates of these institutions are all adults or boys except in one case, the Home for Soldiers' Orphans: in the Reform School the ages are fourteen to seventeen.

The quantities of food per capita were as follows, per annum:

Breadstuffs (all sorts),	281.38 pounds.
Meats and fish,	226.12 "
Butter,	28.99 "
Cheese,	3.26 "

Tea,	2.40 pounds.
Coffee,	7.60 "
Sugar,	36.78 "
Rice and hominy,	5.23 "
Fruit bought by the pound,	10.64 "
Total,	602.40 "
Fruit bought by the quart,	27 quarts.
Vegetables reduced to quarts,	71 "
	98
Oranges and lemons, number,	4
Eggs, number,	91
Molasses, vinegar and cider,	1.22 gallons.

Average prices paid:

Flour (wheat) per barrel,	$6.03
Fresh meat per 100 lbs.,	7.33
Salt meat per 100 lbs.,	5.66
Potatoes per bushel,	.64
Butter per pound, a fraction less than	.22
Tea per pound,	.41
Coffee per pound,	.17
Sugar per pound,	.09
Molasses per gallon,	.49
Eggs per dozen,	.13

The expenses of these institutions during this period were $5,869,189.30, of which salaries constituted $2,094,896.86.

The average charge per inmate has been as high as 59½ cents per day and is now 55 cents; but, including officials and employés, the cost per head, no rent being charged, is 46 cents per day per capita.

If we deduct 25 per cent, as the savings of officials and employés, the remainder, $5,345,515 gives an average cost of about 45 cents per day, expended in food, fuel, clothing, repairs, and general expenses, without rent; or if we reduce the salaries of officials and employés by one-half, we still have an average cost of 41 to 42 cents, or at the present time of 37½ cents per head.

This is surprisingly low, and it proves the economy and effi-

ciency of the management of these institutions; but it brings out in a most conspicuous way the close conditions of existence when we compare these figures with the average expenditure per capita in the families of working people and when we recall the fact that a very large proportion must pay rent as well as provide food, fuel and clothing out of what 40 to 45 cents a day will buy.

Dietary No. 6.

Fifty-six adult females, factory operatives and the employés in charge of the boarding-house, for six months in 1885, in Maryland.

Food bought by the factory owners at wholesale prices.

	CENTS
Meat and fish,	6.51
Milk, butter and cheese,	2.86
Eggs,	.65
Total animal food,	10.02
Vegetables,	1.46
Cereals,	1.73
Sugar and syrup,	1.30
Tea and coffee,	.90
Fruit,	.35
Salt, spice, etc.,	.40
Total cents per day,	16.16

Dietary No. 7.

By the kindness of Mr. L. McHugh, Chief of the Bureau of Labor Statistics of Ohio, I have been furnished with the division of the expenses of twenty-seven mechanics' and miners' families in Ohio whose average expenditures ranged for one year from $300 for 2 persons to $1,194 for 6 persons.

Average persons per family $4\frac{70}{100}$.

Average expenditure per year		$557.14
Average per person per day		$.32\frac{45}{100}$
Subdivision.		
Rent	76.52	
Food and light	261.04	

Clothing including boots and shoes and miscellaneous dry goods	115.42	
Fuel	32.00	
Sickness	20.74	
Sundries	50.42	
		$557.14

Food in this statement costs a little less than 50 per cent of the expenditure at an average of $15\frac{22}{100}$ cents per person per day. At a fair computation this would be at the rate of $17\frac{35}{100}$ cents per day per adult.

Dietary No. 8.

A carder in a woollen mill in Rhenish Prussia, supporting his wife and two children of 6 and 8 years, equal to three adults. (From Consul J. S. Potter's report.)

	PER WEEK.
Breakfast: coffee, bread and butter,	.47½ cts.
Lunch: bread and butter, sometimes a little meat,	.47½
Dinner: soup, potatoes or other vegetables, occasionally a little meat,	1.66
Lunch at 4 p. m.: coffee, bread and butter,	.47½
Supper, 8 p. m.: milk, soup and bread,	.47½
Personal luxuries including beer,	.26
Total per week,	$3.82

Per day for the equivalent of 3 adults .5455
Per day for each adult $18\frac{18}{100}$ cents.

Dietary No. 9.

Condition of a representative workman in a German shoe factory as given in the report of Consul J. S. Potter.

"I am 38 years old and have a wife and three children the oldest 13 and the youngest 6 years of age. I am shoe-dresser in a factory and I am paid 77 cents per day for 12 hours work.

For breakfast we have coffee, bread and butter and some meat for myself.

For dinner: soup with some vegetables and pork.

At 4 o'clock: coffee, bread and sometimes butter.

At 8 o'clock supper: salad, potatoes and bacon sauce and some meat.

My wife earns 94 cents a week and I work extra hours. With our united earnings I can support my family very well and save for the 'sparcasse' from $10 to $12 a year.

My regular yearly wages now amount to $241\frac{33}{100}$.

I pay for rent per year,	32.13
Clothing for self, wife and children,	41.65
For food and fuel, 44 cents per day,	160.27
Government tax,	.72
Beer and tobacco,	6.56
	$241.33

My savings are from extra work. When sick we are furnished with medicine and medical attendance, free of cost, the expense for which is paid from a contribution by my employer and a workman's union in the factory.

At the present time (1885) business is very lively and *wages are high.*"

The italics are my own. It will be observed that the cost of food and fuel is 66⅔ per cent of the expenditure, and if the family is computed at 3½ adults, the cost of food and fuel is $12\frac{57}{100}$ cts. per day.

These two reports give some indications of the comparative conditions of workmen in Germany and in the United States. The money available for food is less in Germany, both in amount and in purchasing power.

Under recent instructions from the Secretary of State, consuls will hereafter report on a uniform plan as to the daily rations of European workmen, giving quantity, price and amount, in a form corresponding to the statements given in this address on the rations in this country.

It needs no argument to prove that the great advantage of this country over all others lies in the huge abundance of the most nutritious food, and since the cost of labor in any given product may be measured by the effectiveness of the labor, rather than by a mere comparison of the rate of wages in money, it becomes important to know the price of food in countries which may compete with us, or which we may be called upon to supply in part.

The problem may be given in these terms:

1. What is the quantity of work performed for a given sum of money?

2. How much of such given sum of money can be devoted to the purchase of food?

3. How much force or energy does such a supply of food represent?

The underfed cannot compete with the well nourished.

So far as the food problem yet affects this country, the only service which science can render is to show what choice should be made as to the kind of food to be purchased, and how it should be prepared.

In Germany, and in many other European states, it has become necessary to teach the people how to get the utmost out of an insufficient supply. For this reason, a great deal of scientific work has been done in Germany, in a direction upon which we have only begun, and the dietary which has been prepared by Dr. Meinert may possess great interest in comparison with both the practice of this country, and the theory which is presented in the table of standard rations given herewith.

The main point of interest is the very limited variety of food, and the somewhat meagre, even if theoretically sufficient, diet which can be had in Germany at a cost of 18¾ cents per day.

For the preparation of translation of the German dietary as well as for all the other tables hereto appended, I am indebted to Prof. Wm. O. Atwater of Middletown, Conn.

I entered upon this statistical inquiry without any full comprehension of the vast importance of the subject. Many of the propositions, which have been generally accepted by economists, such as the law of population propounded by Malthus, the theory of rent of Ricardo, and the so-called law of diminishing returns from land, have never seemed to me to have any true foundation, either in reason or in history, and it was mainly for the purpose of establishing a statistical refutation of these hypotheses that I began to consider the food question.

Upon examining such books as were within my reach, I found the statistics of rations almost wholly wanting, except the data taken from charitable institutions. On consulting the physiologists and biologists, I found that the coöperation of the statisti-

cian was urgently needed by them in the solution of the food problem as it is presented to them.

After consulting with Col. Carroll D. Wright, Chief of the National Bureau of the Statistics of Labor, and presenting the subject for the consideration of the Chiefs of the Labor Bureau of the several states, the following blank was prepared.

THE DAILY RATION OF FOOD OF WORKING PEOPLE IN THE DIFFERENT SECTIONS OF THE COUNTRY.

1. Of what does this ration now consist and what does it cost?

				CENTS.
A.	Meat and Fish.	Quantity,	price,	cost,
B.	Milk.	"	"	"
	Butter.	"	"	"
	Cheese.	"	"	"
	Eggs.	"	"	"
	Total Animal Food.			
C.	Bread: Wheat,	Quantity,	price,	cost,
	Corn or Rye.	"	"	"
D.	Vegetables.	"	"	"
E.	Sugar.	"	"	"
	Molasses or Syrup.	"	"	"
F.	Tea.	"	"	"
	Coffee.	"	"	"
G.	Fruit, green,	"	"	"
	dry.	"	"	"
H.	Salt, Spice, Ice. Pickles and Sundries.	"	"	"
	Totals.			

2. What proportion does the average cost of food bear to the total cost of living?

As I have before stated, a similar inquiry is now being made by the Consular Bureau, and it is possible that before the report of this meeting is finally published, the data included will constitute something more than a beginning of the science of the consumption of food.

I trust that you will be so impressed with the importance of this subject, that you will excuse me for the weary length of this address.

I am requested by Prof. Atwater before presenting even a digest of the material which he has placed in my hands subject to my use, to state, that his numerous engagements since I made the request for this treatise have prevented his doing anything more than to dictate a partial answer to my questions, and there has been no time to consider the form or to revise the substance of what he has given me. It is of the utmost value, and I trust that it will all appear, perhaps in connection with his address lately made to the Chiefs of the Bureaus of Labor Statistics of the United States.

The following pages contain only a portion of the extremely valuable information supplied by Prof. W. O. Atwater upon the subject of *A Standard Ration.*

DATA PREPARED BY PROF. W. O. ATWATER.

In answer to the question "What should be the standard or daily ration?" it may be said that the ordinarily accepted standards are estimated in terms of the three most important classes of the nutritive ingredients, or nutrients of food: (1) protein, or albuminoids; (2) fats; (3) carbo-hydrates.

Our best information upon this subject comes from Germany, accurate experiments having been made by Liebig, Moleschott, Pettenkofer, Voit and others. Payen in France; Frankland, Playfair, Lawes and Gilbert, in England, have also made most valuable contributions to the knowledge upon this subject.

I cannot forbear noting the fact, however, that very little attention appears to have been paid to the results of these experiments on this side of the Atlantic, or, for that matter, in England: even in some of the best text-books in chemistry and physiology, those which are looked upon as most authoritative are too apt to pass the subject over most superficially, or almost to ignore it.

The standard rations assumed by Prof. Voit of Munich are more commonly accepted than any others, and are most frequently quoted and followed in estimating dietaries.

The following are standards adopted by the Munich school of physiological chemists who follow Voit.

STANDARD RATIONS.

	PROTEIN.	FATS.	CARBOHYDRATES.
	grammes	*grammes*	*grammes*
Children to 1½ years.	20–36	30–45	60–90
" from 6 to 15 years.	70–80	37–50	250–400
Laboring man at moderate work.	118	56	500
" " " severe "	145	100	450
Laboring woman.	92	44	400
Aged man.	100	68	350
Aged woman.	80	50	260

We are of course to understand that these figures represent only general averages. It is assumed that for an ordinary laboring man doing an ordinary amount of work, the amounts of nutrients above given will suffice, and that with them he will hold his own; that with much less he will lose flesh and fat, and grow weak; and that any considerable excess above these quantities will be superfluous. But of course no one expects any given man to adjust his diet exactly to this standard; he may need more, and may perhaps get on with less. He may eat more fats and less carbohydrates, and more protein, if he is willing to pay for it. If, however, he eats much less protein, and keeps up his muscular exertion, he will, in Prof. Voit's opinion, be apt, sooner or later, to suffer.

Protein is the costliest of the food ingredients, and hence the one which, from the pecuniary standpoint most needs to be economized; and since, furthermore, its work of building up muscles, tendons and the like, cannot be done by either of the other classes of nutrients, since, in other words, it is very expensive,—one of the first questions in constructing an economical ration is, "What is the least amount of protein that will suffice?" This question cannot be answered exactly until we know more than we now do about the demands of different organisms under different conditions. The subject needs more thorough and experimental study.

To resume briefly. In computing standard rations to supply sufficient food at the minimum cost, we have to learn.

1st.—What is the minimum quantity of the most costly ingredient, viz., protein?

2d.—What proportion of nutrients are contained in the food materials we are to use?

The flavor of the food and the special fitness of the different kinds must of course be considered. We are as yet only on the threshold of our knowledge of these matters. I ought not to dismiss this subject without adding a word upon the digestibility of foods, and the quantities needed. Many experiments have been made to determine the proportions of the different nutrients that are actually digested by a healthy man. Meats and fish are more completely digested than vegetable foods. 99 per cent has been found to be digested by a healthy man, only one or two per cent being wasted, while, of course, of bread one-fourth or one-third might pass through the alimentary canal undigested.

But lack of complete data as well as of time for discussion precludes further reference to the matter.

EXAMPLES OF GERMAN RATIONS, CORRESPONDING TO THIS STANDARD, AND THEIR PRICE.

Of late a great deal of attention has been paid, in Germany, to this particular subject of the food of the people, and the best ways to economize it. I noticed a statement in a scientific journal, a few days ago, that Bismark had engaged Professor König to prepare a series of schedules of rations for ordinary German laboring people, which, I suppose, actually means that one of the departments of the Prussian government has engaged Professor König, who is one of the principal authorities in this line, to carry out this enterprise. Numerous attempts have already been made in this same direction. I have before me, for instance, a little brochure, of about one hundred pages by Dr. Meinert, entitled "*Wie nährt man sich gut und billig?*" "How can one feed himself well and economically." That this is regarded as trustworthy is evinced by the fact that it was honored with a prize, offered by an association and awarded by a committee consisting of Professors Voit, Foster, and Beneke, three of the best known German authorities in this specialty. It tells in plain language about foods, their constituents, the proportions of the several nutrients in various foods, the relative cheapness and dearness of different food materials as shown by the comparison of their composition with their price, and with the rest gives schedules of daily rations for families. There are three of these schedules, the first intended for a family with an annual income of 800 marks, $200.00, of which it is assumed that 60 per cent will be expended

for food. The second is for a family with an income of 1100 marks, or $275.00, and the third for one of 1500 marks, or $375.00 per annum. The outlay for the food of each of the last two is to be about 53 per cent of the income. As the largest of the three incomes would be counted very small with us, I have selected the schedule corresponding to it rather than either of the others, for the translation which I have caused to be made and included herewith.

Dietary for a family for two weeks.

The following dietary is calculated for a family consisting of father, mother and two children of ten and twelve years of age.

The annual income for the support of the family is taken at 1500 marks or $375, of which 53 per cent, 800 marks, per year, or $200 which would allow 220 pfennigs or fifty-five cents per day, is to be spent for food. It is assumed that the mother and two children will require as much nutritive material in their food as two laboring men, so that the family of four persons will be equal in their demand to three laboring men. Dr. Meinert further assumes that to earn so large a sum as 1500 marks per year, more than ordinarily hard work will be required; and hence, following Professor Voit's figures for rations, he provided for a ration with nutrients a little in excess of the standard for a laboring man at moderate work. Professor Voit's standards for an ordinary laboring man doing moderately hard work, and for the same man at severe work, are stated below and with them Dr. Meinert's standard for the family in question.

NUTRIENTS IN DAILY RATION.

Nutrients.	PROF. VOIT'S STANDARDS.		Dr. Meinert's standard for family with 1500 marks per year.
	For laboring man at moderate work.	For laboring man at severe work.	
Protein.	118 grams (0.26 lb.)	145 grams.	120 grams.
Fats.	56 " (0.12 lb.)	100 "	70 "
Carbohydrates.	500 " (1.10 lbs.)	450 "	500 "

As the family are accounted equivalent to three "laboring men" the 220 pfennigs allowed for food per day must pay for three rations which gives 73.3 pfennigs per ration. The problem then is

to draw up a bill of fare for each day, which shall furnish a minimum of 120 grams or 0.27 lbs. of protein, 70 grams or 0.15 lbs. of fats, and 500 grams or 1.10 lbs. of carbohydrates for 73.3 pfennigs or 18¾ cents per day, in food materials such as a German laborer may properly use and at such prices as he must pay for them.

In accordance with German usage provision is to be made for breakfast, dinner at midday, lunch (Vesperbrot) in the afternoon and supper (Abendessen). The following is Dr. Meinert's outline of the bill of fare for two weeks.

BILL OF FARE FOR FOURTEEN DAYS.

DAY.	BREAKFAST.	DINNER.	LUNCH.	SUPPER.
1st	Coffee, milk, rolls, black bread, butter.	Fresh haddock with mustard sauce and potatoes.	Coffee and milk. Bread and butter.	Meat and vegetable soup.
2d	"	Beef stew with Kohlrabi and potatoes.	"	Cheese and beer.
3d	"	Sausage with and beer.	"	Onion soup.
4th	"	Mutton and beans.	"	Potato soup.
5th	"	with bacon and beer.	"	Pea soup.
6th	"		"	Herring and beer.
7th	"	Dried codfish with sauerkraut, pease and beer.	"	Buttermilk soup.
8th	"	Hashed meats with potato soup.	"	Meat and vegetable soup.
9th	"	Sausage (*Bludwurst*) with lentils and beer.	"	Potatoes and
10th	"	Liver with potato salad.	"	Cheese and beer.
11th	"	Beefsteak with cabbage and potatoes.	"	Bread and milk soup.
12th	"	Herring, potatoes and beer.	"	Meat and vegetable soup.
13th	"	Pork with cabbage and potatoes.	"	Cheese and beer.
14th	"	Liver with spinach, potatoes and beer.	"	Oatmeal in buttermilk.

The details of the daily bills of fare are given by Dr. Meinert in the forms translated beyond. The quantities are given in the metric weights and measures current in Germany. It will be remembered that the kilogram consists of 1,000 grams and equals about 2.2 lbs.; that the gram is nearly 15.5 grains, and roughly speaking, 450 grams make a pound and 28 grams an ounce. The liter is 1,000 cubic centimeters, a little over a quart; a liter of water weighs 1 kilogram. The mark consists of 100 pfennigs and is worth about twenty-five cents, so that the pfennig is one-quarter of a cent. Translating these into our own weights and measures would, I think, rather detract from than add to their clearness and value. In their present form they are simple, but would by recalculation become more complex. In the summary at the end the quantities and prices are given in American weights and money.

In translating I will for convenience speak of the first and second breakfast together as breakfast. The midday and evening meals we will call dinner and supper and will follow Dr. Meinert's example in including the afternoon lunch with breakfast.

In this dietary Dr. Meinert gives first a general schedule for breakfast and lunch, which (or its equivalent) is to serve for each of the fourteen days. The schedule for dinner and supper for each several day is given by itself. It is assumed that the material left over at one time will serve for another, and that thus the evening meals may be filled out from what is left at breakfast or dinner.

BREAKFAST AND LUNCH.

AMOUNT OF FOOD AND PRICE.	AMOUNT IN GRAMS.	Price per kilo or liter in pfennigs.	Price of the amount indicated in pfennigs.	AMOUNT OF		
				Protein. grams.	Fats. grams.	Carbo-hydrates. grams.
4 Wheat rolls.	290		12	15	2	148
Rye bread.	1500	24	36	90	9	750
Coffee and trimmings.	60		9	5	1	28
1½ liters skimmed milk.	1250	8	10	38	6	50
Butter.	100	240	24		98	
Salt.	75	20	1.5			
2 liters beer.	2000	12	24	10		160
			116.5	158	116	1136
Per head and day.			38.8	53	39	379
There remains for dinner and supper.			34.5	67	31	121
Total per head per day			73.3	120	70	500

It will be observed that the cost of each material is stated, with the amounts of nutrients it contains. By "per head" is understood for one laboring man. It will be remembered that the mother and two children were assumed to require as much as two laboring men.

Here follow details of dinner and supper, and summary for each of the 14 days.

BILL OF FARE FOR DINNER AND SUPPER FOR FOURTEEN DAYS.

AMOUNT OF FOOD	Amount in grams.	Price per kilo or liter in pfennigs.	Price of the amount indicated in pfennigs.	AMOUNT OF			
				Protein grams.	Fats grams.	Carbohydrates grams.	
Fresh haddock.	500	80	40	60	5	8	FIRST DAY. Dinner.—Cod fish with mustard sauce and potatoes.
Mustard.	125	80	10	33	42	31	
Flour.	50	40	2	6	—	35	
Fat (lard, butter)	60	130	8	—	57	—	
Potatoes.	2500	7	17.5	50	3	500	Supper.—Meat and vegetable soup.
"Fleischgemüse"[1]	125	200	25	40	22	44	
			102.5	189	129	618	
Per head.			34.2	63	43	206	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			73.0	116	82	585	
Beef.	500	120	60	80	40	—	SECOND DAY. Dinner.—
Fat (lard, butter, etc.)	100	130	13	—	95	—	
Kohlrabi.	1000	15	15	27	2	86	
Potatoes.	1500	7	10.5	30	3	300	
Skim-milk cheese	300	50	15	120	21	—	Supper.—Cheese and beer.
			113.5	257	161	386	
Per head.			37.8	86	54	129	
For breakfast lunch, etc.			38.8	53	39	379	
Total per head and day.			76.6	139	93	508	

[1] "Fleischgemüse," soup made from a mixture of preserved South American meat and vegetables especially recommended by Dr. Meinert.

Amount of food.	Amount in grams.	Price per kilo or liter in pfennigs.	Price of the amount indicated in pfennigs.	Amount of			
				Protein grams.	Fats. grams.	Carbohydrates. grams.	
Millet.	500	40	20	56	17	290	THIRD DAY. Dinner.—
Skimmed milk.	1500	8	12	45	7	60	
Sausage.	300	180	54	69	33	21	
Onions.	150	10	1.5	4	—	12	
Fat.	50	130	6.5	—	47	—	
Flour.	150	40	6.0	17	2	105	Supper.— Onion soup.
			100.0	191	106	488	
Per head.			33.3	64	35	163	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			72.1	117	74	542	
Mutton.	500	120	60	75	50	—	FOURTH DAY. Dinner.— Mutton and beans.
Beans.	500	40	20	150	10	250	
Fat.	100	130	13	—	95	—	
Potatoes.	2000	7	14	40	2	400	Supper.— Potato soup.
			107	245	157	650	
Per head.			35.6	82	52	216	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			74.4	135	91	595	
"Fleischgraupen"	450	150	68	160	10	300	FIFTH DAY. Dinner.—
Bacon.	125	160	20	3	98	—	
Pease.	300	50	15	67	6	150	
Lard.	40	170	7	—	37	—	Supper.— Pea soup.
Spices.	—	—	2	—	—	—	
			112	170	151	450	
Per head.			37.3	57	50	150	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			76.1	110	89	529	

AMOUNT OF FOOD.	Amount in grams.	Price per kilo or liter in pfennigs.	Price of the amount indicated in pfennigs.	AMOUNT OF			
				Protein grams.	Fats. grams.	Carbohydrates. grams.	
Wheat flour.	600	45	27	66	6	438	SIXTH DAY. Dinner.— Dumplings with fruit.
Potatoes.	1500	7	10.5	30	1.5	300	
Wheat rolls.	72	—	3	4	—	35	
Fat.	100	130	13	—	95	—	
Fruit.	250	80	20	8	2.5	113	
Sugar.	30	100	3	—	—	27	Supper.— Herring and beer.
Herrings.	200	7	21	52	32	5	
			97.5	100	137.0	918	
Per head.			32.5	53	46	306	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			71.3	106	85	685	
Dried codfish.	250	140	35	198	3	—	SEVENTH DAY. Dinner.—Dried codfish, with sauerkraut, pease and beer.
Sauerkraut.	1000	18	18	10	2	46	
Pease.	300	50	15	67	3	150	
Fat.	100	130	13	—	95	—	
Buttermilk, 2 liters.	2000	6	12	51	15	15	Supper.— Butter milk soup.
			93	326	118	211	
Per head.			31	109	39	70	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			69.8	162	78	449	

AMOUNT OF FOOD.	Amount in grams.	Price per kilo or liter in pfennigs.	Price of the amount indicated in pfennigs.	AMOUNT OF			
				Protein grams.	Fats grams.	Carbohydrates. grams.	
Beef.	200	120	24	32	16	—	EIGHTH DAY. Dinner.—Hashed meats with potato soup.
Pork.	100	130	13	14	10	—	
Mutton.	125	120	15	20	8	—	
Fat.	60	120	8	—	56	—	
Spices and vegetables.	40	3	—	—	—	—	
Potatoes.	3000	7	21	60	3	600	Supper.—Meat and vegetable soup.
"Fleischgemüse."	125	200	25	40	22	46	
			106	166	115	646	
Per head.			35.3	55	38	215	
For breakfast, lunch, etc.			38.5	53	39	379	
Total per head and day.			74.1	108	77	594	
Sausage.	300	160	48	35	34	78	NINTH DAY. Dinner.—Sausage and lentils.
Lentils.	500	50	25	125	10	250	
Vinegar.	—	—	3	—	—	—	
Curd.	250	40	10	43	8	7	Supper.—Potatoes and curd.
Potatoes.	2500	7	17.5	50	3	500	
			103.5	253	55	835	
Per head.			34.5	84	18	278	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			73.3	137	57	657	

AMOUNT OF FOOD	Amount in grams.	Price per kilo or liter in pfennigs.	Price of the amount indicated in pfennigs.	AMOUNT OF			
				Protein grams.	Fats. grams.	Carbohydrates grams.	
Liver and lungs.	500	80	40	97	27	10	TENTH DAY. Dinner.—Liver with potato salad.
Lard.	40	1.70	6.8	—	36	—	
Wheat rolls.	156	—	6	6	1.5	78	
Flour.	40	40	1.6	4	0.5	28	
Onions.	50	10	.5	1	—	4	
Pepper and vegetables.	60	—	1.6	—	—	—	
Potatoes.	2500	7	17.5	50	2.5	500	
Vinegar and oil.	—	—	5	—	—	—	
Cheese.	300	50	15	120	21	—	Supper.—Cheese and beer.
			94.0	278	88.5	620	
Per head.			31.3	93	29	207	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			70.1	146	68	586	
Beefsteak.	400	160	64	88	20	—	ELEVENTH DAY. Dinner.—Beefsteak with cabbage and potatoes.
Lard.	60	170	10	—	57	—	
Red cabbage.	1000	15	15	18	2	70	
Potatoes.	1500	7	10.5	30	1	300	
Bread.	300	24	7	18	3	150	Supper.—Bread and milk soup.
Skimmed milk.	1500	8	12	45	7	60	
			118.5	199	90	580	
Per head.			39.5	63	30	193	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day			78.3	116	69	572	

AMOUNT OF FOOD.	Amount in grams.	Price per kilo or liter in pfennigs.	Price of the amount indicated in pfennigs.	AMOUNT OF			
				Protein grams.	Fats. grams.	Carbohydrates. grams.	
Three herrings.	200	7[2]	21	52	32	5	TWELFTH DAY. Dinner.— Herring and potatoes, beer.
Potatoes.	3000	7	21	60	3	600	
Skimmed milk.	1000	8	8	30	4	40	
Flour.	50	40	2	5	0.5	35	
Onions.	50	10	0.5	1	0.5	3	
Lard.	50	170	8.5	—	47	—	
Spices.	—	—	1.5	—	—	—	
"Fleischgemüse."	125	200	25	40	23	46	Supper.— Meat and vegetable soup.
			87.5	188	109.0	729	
Per head.			29.2	63	36	243	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			68.0	116	75	622	
Pork.	500	130	65	67	60	—	THIRTEENTH DAY. Dinner.— Pork with white cabbage and potatoes.
Cabbage.	1000	10	10	20	1	66	
Potatoes.	2000	7	14	40	2	400	
Lard.	50	170	8.5	—	47	—	
Cheese.	300	50	15	120	21	—	Supper.— Cheese and beer.
			112.5	247	131	466	
Per head.			37.5	82	44	155	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			76.3	135	83	534	

[2] At 7 pfennigs each.

AMOUNT OF FOOD	Amount in grams.	Price per kilo or liter in pfennigs.	Price of the amount indicated in pfennigs.	AMOUNT OF			
				Protein grams.	Fats. grams.	Carbohydrates grams.	
Liver.	500	100	50	175	15	—	FOURTEENTH DAY. Dinner.—Liver with vegetables and potatoes, beer.
Spinach.	1000	15	15	20	2	60	
Potatoes.	2000	7	14	40	2	400	
Fat.	80	130	10	—	75	—	
Oatmeal.	150	60	9	23	9	96	Supper.—Oatmeal in butter milk.
Buttermilk.	1000	6	6	34	10	10	
			104	292	113	566	
Per head.			35	97	38	189	
For breakfast, lunch, etc.			38.8	53	39	379	
Total per head and day.			73.8	150	77	568	

RATIONS OF COMMON FOOD MATERIALS ESTIMATED TO CONTAIN THE AMOUNTS OF NUTRITIVE INGREDIENTS IN THE STANDARD RATION, WITH COST OF EACH.

The following rations have been calculated by my assistant, Mr. Rockwood, mostly from results of analysis made in our laboratory in behalf of the Smithsonian Institution (U. S. National Museum) as a basis for its explanation of its food collection. No other considerable series of analysis of American food materials has, so far as I am aware, been executed, hence, though the data are meagre they are the best available; they are probably not far out of the way. Mr Rockwood has endeavored to construct one series of rations at a very low cost, eleven or twelve cents a day or thereabouts, and another series at higher rates, up to forty-five cents a day. Of course it is not proposed that any person or family should attempt to follow these exactly. For that matter the chemist will evidently have to consult the cook if he proposes to construct rations to accord with ordinary tastes. The rations will, nevertheless, help to show how foods may be economized, and what proportions would suffice for the nourishment of ordi-

nary people, and what are the constituents and costs of the different materials.

DAILY RATIONS COMPUTED TO FURNISH NUTRIENTS EQUIVALENT TO THOSE OF STANDARD FOR LABORING MAN AT MODERATE WORK.

Standard Ration:—Protein (118 grams) 0.26 lb.; fats (56 grams) 0.12 lbs.; carbohydrates (500 grams) 1.10 lbs.

A. Daily Rations costing 12 cents or less.

Food materials.			Food materials.		
Kinds.	Amounts.	Costs.	Kinds.	Amounts.	Costs.
No. 1.			**No. 6.**		
Beef, neck,	¼ lb.	4 cts.	Smoked herring,	¼ lb.	3 cts.
Beans,	¼ "	¾ "	Potatoes,	1 "	1 "
Potatoes,	2 "	2 "	Beans,	¼ "	1¼ "
Oatmeal,	¼ "	1½ "	Wheat flour,	1 "	4 "
Butter,	½ oz.	1¼ "	Butter,	1-16 "	2 "
Rye flour,	¼ lb.	1½ "	Total,		11¼ "
Total,		10¾	**No. 7.**		
No. 2.			Beef, neck,	¼ lb.	4 cts.
Beef, shin,	¼ lb.	3 cts.	Beef, shin,	" "	3 "
Oatmeal,	" "	2½ "	Alewives,	1 "	3 "
Corn meal,	" "	1 "	Beans,	¼ "	¾ "
Milk, ½ pt.,	" "	2 "	Milk, ½ pt.,	½ "	2 "
Potatoes,	1 lb.	1 "	Rye flour,	" "	1½ "
Butter,	1 oz.	2 "	Wheat flour,	" "	2 "
Total,		11½ "	Oatmeal,	¾ "	3¾ "
No. 3.			Corn meal,	1 "	3 "
Herring,	¼ lb.	3 cts.	Potatoes,	5 "	5 "
Oatmeal,	¼ "	1¼ "	Butter,	2¾ oz.	5½ "
Potatoes,	1 "	1 "	Total, for 3 men,		33¼ "
Wheat flour,	1 "	4 "	" " 1 man,		11
Butter,	1-16 "	2 "	**No. 8.**		
Total,		11¼ "	Beef, neck,	¼ lb.	4 cts.
No. 4.			Beef, shin,	" "	3 "
Beef, shin,	¼ lb.	3 cts.	Rye flour,	" "	1½ "
Potatoes,	3 "	3 "	Sugar,	1½ oz.	1 "
Wheat flour,	¼ "	2 "	Oatmeal,	½ lb.	2½ "
Beans,	¼ "	¾ "	Herring,	1 "	6 "
Butter,	1-16 "	2 "	Beans,	10 oz.	2½ "
Sugar,	1 ½ oz.	1 "	Wheat flour,	2½ lb.	10 "
Total,		11¾ "	Potatoes,	7 "	7 "
No. 5.			Butter,	3¼ oz.	7¼ "
Alewives,	1 lb.	3 cts.	Total, for 4 men,		44¾ "
Potatoes,	2 "	2 "	" " 1 man,		11¾ "
Corn meal,	½ "	1½ "			
Wheat flour,	½ "	2 "			
Butter,	1-16 "	2 "			
Total,		10½ "			

B. Daily rations costing from 12 *to* 15 *cents.*

Food-materials.			Food-materials.		
Kinds.	Amounts.	Costs.	Kinds.	Amounts.	Costs.
No. 9.			No. 14.		
Liver,	¼ lb.	5 cts.	Fresh mackerel,	¾ lb.	4½ cts.
Potatoes,	1 "	1 "	Potatoes,	1 "	1 "
Butter,	1-16"	2 "	Cracked wheat,	½ "	3 "
Cornmeal,	1 "	3 "	Cornmeal,	" "	1½ "
Bread,	½ "	3 "	Beans,	½ "	¾ "
Total,		14 "	Butter,	1 oz.	2 "
No. 10.			Total,		12¾ "
Beef, shin,	½ lb.	3 "	No. 15.		
Bread,	½ "	2½ "	Beef, neck,	½ "	4 cts.
Potatoes,	1 "	1 "	Potatoes,	1 "	1 "
Oatmeal,	½ "	1½ "	Cornmeal,	½ "	1½ "
Cornmeal,	½ "	1½ "	Rye bread,	1 "	4 "
Butter,	1-16"	1 "	Butter,	1 oz.	2 "
Sugar,	1-32"	¼ "	Total,		12½ "
Milk,	½ "	2 "	No. 16, for 3 men.		
Total,		13½ "	Liver,	½ "	5 "
No. 11.			Beef, shin (soup),	" "	3 "
Salt cod,	½ lb.	3½ "	Salt codfish,	" "	3½ "
Oatmeal,	" "	2½ "	Salt pork,	2 oz.	2 "
Cornmeal,	" "	1 "	Crackers (pilot),	1 lb.	5½ "
Milk,	" "	2 "	Pease,	½ "	3 "
Butter,	1 oz.	2 "	Sugar,	½ oz.	½ "
Potatoes,	2 lbs.	2 "	Milk,	½ lb.	2 "
Total,		13 "	Oatmeal,	" "	1½ "
No. 12.			Potatoes,	2 lbs.	2 "
Pork,	½ lb.	2 "	Bread,	1 "	6 "
Beans,	½ "	1½ "	Butter,	2 oz.	4 "
Salt cod,	" "	2 "	Cornmeal,	1½ lb.	4½ "
Potatoes,	1½ lbs.	1½ "	Total, for 3 men,		42 "
Bread,	1½ "	6 "	" " 1 man,		14 "
Total,		12¾ "	No. 17, for 4 men.		
No. 13.			Beef, shin,	½ lb.	3 "
Salt codfish,	½ lb.	3½ "	Fresh mackerel,	½ "	4½ "
Salt pork,	½ "	2 "	Salt cod,	" "	5½ "
Crackers (pilot),	1 "	5½ "	Pork,	2 oz.	2 "
Pease,	½ "	3 "	Beans,	½ lb.	1½ "
Total,		14 "	Wheat bread,	1½ "	8½ "
			Cracked wheat,	½ "	3 "
			Cornmeal,	1½ "	4½ "
			Oatmeal,	½ "	4 "
			Butter,	3 oz.	6 "
			Milk,	½ lb.	4 "
			Potatoes,	5½ "	5½ "
			Sugar,	½ oz.	½ "
			Total, for 4 men,		52½ "
			" " 1 man,		13 "

C. Daily rations costing from 15 to 20 cents.

Food-materials.			Food-materials.		
Kinds.	Amounts.	Costs.	Kinds.	Amounts.	Costs.
No. 18.			No. 22.		
Beef, neck,	¼ lb.	2 cts.	Pork,	½ oz.	½ "
Salt cod,	" "	1½ "	Beans,	3 "	2 "
Potatoes,	1 "	1 "	Fresh cod,	¼ lb.	3½ "
Bread,	¼ "	3 "	Potatoes,	1½ lbs.	1½ "
Cabbage,	2 oz.	½ "	Rye bread,	1 "	4 "
Turnips,	" "	½ "	Butter,	1 oz.	2 "
Carrots,	" "	" "	Sugar,	2 "	1½ "
Oatmeal,	" "	½ "	Milk,	1 lb.	3½ "
Milk, 1 pt.,	1 lb.	3½ "	Total,		18½ "
Rice,	2 oz.	1½ "			
Sugar,	" "	1½ "			
Corn meal,	½ lb.	½ "	No. 23, for 3 men.		
Soda crackers,	1 oz.	" "			
Butter,	" "	2 "	Round steak,	½ lb.	9 cts.
Total,		18 "	Beef, neck,	¼ "	2 "
			Fresh haddock,	¼ "	3½ "
No. 19.			Salt cod,	¼ "	1½ "
			Fat pork,	½ oz.	½ "
Round steak,	½ lb.	8 "	Beans,	3 "	2 "
Milk,	" "	2 "	Milk,	2½ lbs.	9 "
Butter,	1 oz.	" "	Cheese,	1 oz.	1 "
Cheese,	" "	1 "	Butter,	3 "	6 "
Bread,	¼ lb.	2½ "	Wheat bread,	1 lb.	5 "
Potatoes,	1½ lbs.	1½ "	Rye bread,	" "	4 "
Sugar,	1½ oz.	1 "	Soda crackers,	" oz.	½ "
Turnips,	¼ lb.	½ "	Oatmeal,	2 "	½ "
Cornmeal,	½ "	1 "	Cornmeal,	7-12 lb.	1½ "
Total,		19½ "	Rice,	2 oz.	1½ "
			Carrots,	" "	½ "
No. 20.			Turnips,	10 "	½ "
			Potatoes,	4 lbs.	4 "
Beef, shin,	½ lb.	1½ "	Cabbage,	2 oz.	½ "
Fresh cod,	½ "	4 "	Sugar,	5½ "	3½ "
Oatmeal,	½ "	½ "	Total, for 3 men,		46½ "
Bread,	½ "	3 "	" " 1 man,		15 "
Butter,	1 oz.	2 "			
Potatoes,	1 lb.	1 "	No. 24, for 3 men.		
Boston crackers,	2 oz.	1½ "			
Milk, 1-2 pint,	½ lb.	1½ "	Round steak,	½ lb.	9 "
Cornmeal,	" "	" "	Beef, shin (soup),	½ "	1½ "
Total,		16½ "	Fat pork,	1 oz.	1 "
			Fresh cod,	½ lb.	4 "
			Cheese,	1 oz.	1 "
			Milk,	1 lb.	3½ "
			Beans,	½ "	5 "
			Pease,	½ "	2½ "
No. 21.			Wheat bread,	1½ "	7½ "
			Rye bread,	½ "	2 "
Beef, neck,	½ lb.	4½ "	Boston crackers,	2 oz.	1½ "
Milk,	" "	2 "	Oatmeal,	" "	½ "
Cheese,	1 oz.	1 "	Cornmeal,	5-6 lbs.	2½ "
Bread,	1 lb.	5 "	Potatoes,	2½ "	2½ "
Potatoes,	2 "	2 "	Turnips,	½ "	½ "
Sugar,	1½ oz.	1 "	Butter,	3 oz.	6 "
Total,		15½ "	Sugar,	3½ "	2½ "
			Total, for 3 men,		53½ "
			" " 1 man,		18 "

D. Daily rations costing from 20 to 45 cents.

Food Materials.			Food Materials.		
Kinds.	Amounts.	Costs.	Kinds.	Amounts.	Costs.
No. 25, for 4 men.			Potatoes.		
Round steak,	½ lb.	9 cts.	Cauliflower,		
Beef, shin (soup),	¼ "	1½ "	Rice,		
Beef, neck,	" "	2 "	Oyster crackers,		
Fresh cod,	1 "	8 "	Sugar,		
Salt cod,	¼ "	1½ "	Butter,		
Pork,	½ oz.	½ "	Total		
Beans,	½ lb.	5 "			
Wheat bread,	1½ "	8 "	**No. 29.**		
Rye bread,	1 "	4 "			
Boston crackers,	2 oz.	1½ "	Mutton, leg,		
Soda crackers,	1 "	½ "	Oysters,		
Oatmeal,	1 lb.	5 "	Pease,		
Cornmeal,	¾ "	2½ "	Potatoes,		
Rice,	2 oz.	1½ "	Oatmeal,		
Potatoes,	5½ lbs.	5½ "	Rice,		
Cabbage,	2 oz.	½ "	Bread,		
Turnips,	" "	½ "	Oyster crackers		
Carrots,	" "	½ "	Butter,		
Butter,	3 "	6 "			
Milk,	2¼ lbs.	7½ "			
Sugar,	3½ oz.	2½ "			
Total for 4 men,		71½ "			
" " 1 man,		18 "			
No. 26.			Turkey,		
Beef (soup),	¾ lb.	6 cts.			
Potatoes,	1 "	1 "			
Bread,	½ "	3 "	Milk,		
Cabbage,	2 oz.	½ "			
Turnips,	2 "	½ "			
Carrots,	2 "	½ "			
Oatmeal,	2 "	½ "			
Milk,	1 lb.	3½ "			
Rice,	2 oz.	1½ "			
Sugar,	2 "	1½ "			
Corn meal,	½ lb.	½ "			
Soda crackers,	½ "	½ "			
Butter,	1 oz.	2 "			
Total		20½ "			
No. 27.					
Shad,	½ lb.	4 cts.			
Eggs,	¼ "	4 "			
Oatmeal,	2 oz.	½ "			
Rice,	2 "	1½ "			
Beans,	½ lb.	1½ "			
Bread,	½ "	3 "			
Potatoes,	1 lb.	1 "			
Soda crackers,	½ "	2½ "			
Sugar,	2 oz.	1½ "			
Butter,	1 "	2 "			
Total		21½ "			
No. 28.					
Beef, round,	½ lb.	4½ cts.			
Shad,	½ "	4 "			
Pease,	½ "	2½ "			

PECUNIARY ECONOMY OF FOODS.

I have been permitted by Professor Atwater to incorporate the following statements and tables, which have been long in preparation by him, with my address. I do so with the more satisfaction since he has assured me that the time has come when the services of the economist and the statistician are much needed to sustain the work of the chemist and the physiologist.

E. A.

A. COST OF PROTEIN.

A subject that has received but little attention in this country, though it has become a vital one in Europe, and is becoming so with us, is the cost of the nutritive material of our foods. The relative cheapness or dearness of different foods must be judged by comparing, not the prices per pound, but the costs of the actual nutrients. In making such comparisons, the cost may be assumed to fall, not upon the inedible portions and the water, but solely upon the three classes of nutrients, the protein, fats, and carbohydrates.

The relative physiological values of the nutrients in different foods depend upon (1) their digestibility and (2) their functions and the proportions in which they can replace each other in nutrition. An accurate physiological valuation is, in the present state of our knowledge, at least, impracticable. The pecuniary costs of the nutrients are, however, more nearly capable of approximation.

Various methods have been proposed for computing the relative pecuniary costs of the nutrients of foods, none of which, however, are entirely beyond criticism. The following, based upon German estimates of the relative costs of protein fats and carbohydrates, is perhaps as satisfactory as any. They are those of Prof. König.

From extended comparisons of the composition and market prices of the more important animal and vegetable food materials, such as meats, fish, flour, etc., those which serve for nourishment and not as luxuries and form the bulk of the food of the people, it has been estimated that a pound of protein costs, on the average, five times as much, and a pound of fats three times as much, as a pound of carbohydrates; that, in other words, these three classes

of nutrients stand related to each other, in respect to cost, in the following proportions:

Assumed ratios of costs in staple foods

Protein, . .	5
Fats, . .	3
Carbohydrates, .	1

Perhaps a study of foods and prices in our markets might lead to a different scale of valuations, but this will serve our present purpose.

Suppose a pound of beef to cost 25 cents, and to contain 25 per cent of inedible matters, bone, etc., 45 per cent of water, and 30 per cent of nutritive substance, upon which latter—the bone and water being assumed to be without nutritive value—the whole cost comes. The 30 per cent or $\frac{30}{100}$ pounds of nutritive substance thus costs 25 cents, or at the rate of 83½ cents per pound. If now we leave out of account the minute quantities of carbohydrates and the mineral matters, the whole cost will fall upon the protein and fats. Assuming these to cost in the ratio of 5 : 3 and the amounts in the meat to be: protein 15 per cent, and fats 14½ per cent, an easy computation will show the protein to cost 106 cents and a pound of fats 64 cents.

Of the different nutrients, protein is physiologically the most important as it is pecuniarily the most expensive. For these reasons the cost of protein in different food materials may be used as a means of comparing their relative cheapness or dearness, as is done in the following table. The figures represent the ordinary prices per pound and the corresponding costs of protein, in specimens of food materials obtained in New York and Middletown, Conn., markets. Though the number of specimens is too small for reliable averages, the figures, taken together, doubtless give a tolerably fair idea of the relative costliness of the nutrients in the different classes of foods. It will of course be understood that the computations make allowance for the costs of the other nutrients, the fats and the carbohydrates, though for the sake of brevity the latter are omitted from the table.

COMPARATIVE COST OF PROTEIN IN FOOD MATERIALS.

FOOD MATERIALS.	At prices per pound.	Cost of protein per pound.	FOOD MATERIALS.	At prices per pound.	Cost of protein per pound.
	cts.	cts.		cts.	cts.
Salmon.	100	511	Salt mackerel.	12.5	53
Oysters, 50 cts. per quart.	25	336	Smoked ham.	18	51
Oysters, 40 " " "	20	269			
Oysters, 30 " " "	15	202	Smoked ham.	15	43
Lobsters.	12	202	Salt cod.	7	43
Eggs, 40 cts. per doz.	28	157	Mackerel.	5	40
Salmon.	30	153	Wheat bread.	8	38
Flounder.	8	149	Rice.	9	38
Beef, sirloin.	25	06	Cheese, whole milk.	18	37
Eggs, 25 cts. per doz.	18	101	Salt cod.	6	37
Shad.	12	99	Corned beef, lean.	10	26
Bluefish.	10	98	Beef, flank.[3]	15	35
Lake trout.	15	92	Beef, neck.	8	33
Mutton, leg.	22	91	Pork very fat,[3] salted.	16	33
Beef, sirloin.	20	86	Salt cod.	5	31
Halibut.	15	85	Potatoes,[3] $1.00 per bu.	1.7	30
Haddock.	7	84	Wheat bread.	6	29
Mutton, leg.	20	82	Cheese, whole milk.	13	27
Mackerel.	10	79	Alewives.	3	27
Cod.	8	75	Pork, very fat,[3] salted.	12	25
Mutton, side.	20	73	Smoked herring.	6	24
Beef, round.	18	70	Potatoes,[3] 75 cts. per bu.	1.38	23
Canned salmon.	20	70	Wheat bread.	4	19
Mutton, leg.	16	66	Beans, 13 cts. per quart.	6.5	18
Shad.	8	66	Cheese, skimmed milk.	8	18
Corned beef, lean.	18	66	Wheat flour.	4.5	17
Eggs, 15 cts. per doz.	11	62	Wheat flour.	4	15
Milk, 8 cts. per quart.	4	01	Oatmeal.	5	15
Beef, round.	15	59	Beans, 10 cts. per quart.	5	14
Cod.	6	56	Potatoes,[3] 50 cts. per bu.	0.85	14
Corned beef, lean.	15	55	Wheat flour.	3.5	13
Milk, 7 cts. per quart.	3.5	53	Corn meal.	3	13

[3]Containing very little protein, the chief value being in the other ingredients.

Thus the nutrients of vegetable foods are, in general, much less costly than in animal foods. The animal foods have, however, the advantage of containing a larger proportion of protein and fats, and the protein, at least, in more digestible forms.

Among the animal foods, those which rank as delicacies are the costliest. By the above calculations, the protein in the oysters costs from two to three dollars, and, in salmon, rises to over five dollars per pound. In beef, mutton, and ham, it varies from 106 to 43 cents; in shad, blue-fish, haddock and halibut, the range is about the same; while in cod and mackerel, fresh and salted, it varies from 75 to as low as 31 cents per pound. Salt cod and salt mackerel are nearly always, fresh cod and mackerel often, and even the choicer fish, as blue-fish and shad, when abundant, cheaper sources of protein than any but the inferior kinds of meat. Among meats, pork is the cheapest; but salt pork or bacon has the disadvantage of containing very little protein.

It is well worth the noting that oat meal is one of the cheapest foods that we have; that is, it furnishes more nutritive material, in proportion to the cost, than almost any other. Corn meal is indeed cheaper, but the oat meal has this great advantage over corn meal and wheat flour, that it has more protein. Of course, if we are to eat large quantities of lean meat—and most of us, I think, eat more than is best for our health, saying nothing of our purses, the extra protein in the oat meal is of little consequence to us. But if one wishes to economize in his food, oat meal—rightly cooked—affords an excellent material therefor.

One of the most interesting things brought out in the table is cheapness of the staple vegetable food materials, such as potatoes, wheat flour, corn meal, oat meal and beans.

B. AMOUNTS OF NUTRIENTS OBTAINED FOR TWENTY-FIVE CENTS IN DIFFERENT FOOD MATERIALS.

The above method of computing the relative expensiveness of different kinds of food materials is, as I have said, open to the objection that it is based upon a certain assumed ratio of relative costs of protein, fats, and carbohydrates, which may or may not be right in any given case. A method free from these objections consists in computing how much of the several nutrients may be obtained for a given sum, for instance, twenty-five cents, in different food materials. This is done in the following table.

AMOUNTS OF NUTRIENTS FURNISHED FOR TWENTY-FIVE CENTS IN FOOD MATERIALS AT ORDINARY PRICES.

FOOD MATERIALS.	At prices per pound.	25 CENTS WILL PAY FOR:—				
		Total food materials.	NUTRIENTS, POUNDS.			
			Totals.	Protein	Fats.	Carbohydrates.
	cts.	lbs.				
Salmon.	100	25	.06	.01	.02	—
Oysters, 50 cts. per quart.	25	1.00	.12	.06	.03	.04
Oysters, 35 cts. per quart.	17.5	1.42	.17	.09	.02	.06
Salmon.	30	.83	19	.12	.07	—
Bluefish.	10	2.50	.27	.25	.02	—
Beef, sirloin.	25	1.00	.29	.15	.14	—
Shad.	12	2.08	.29	.19	.10	—
Cod.	08	3.13	.34	.33	.01	—
Mutton, leg.	22	1.14	.34	.17	.17	—
Mackerel.	10	2.50	.35	.25	.10	—
Beef, sirloin.	20	1.25	.37	.19	.18	—
Mutton, leg.	20	1.25	.38	.19	.19	—
Beef, round.	18	1.39	.40	.29	.11	—
Canned salmon.	20	1.25	.44	.25	.19	—
Shad.	08	3.13	.44	.29	.15	—
Cod.	06	4.17	.45	.44	.01	—
Mutton, side.	20	1.25	.46	.17	.29	—
Beef, round.	15	1.67	.49	.35	.14	—
Salt cod.	07	3.57	.58	.57	.01	—
Salt mackerel.	12.5	2.00	.60	.30	.30	—
Mackerel.	05	5.00	.71	.51	.20	—
Butter.	30	.83	.73	—	.73	—
Milk, 8cts. per quart.	04	6.25	.74	.21	.23	.30
Salt cod.	05	5.00	.82	.80	.02	—
Milk, 7cts. per quart.	03.5	7.14	.84	.24	.26	.34
Cheese, whole milk.	18	1.39	.10	.38	.49	.03
Beef, neck, whole.	08	3.13	.92	.48	.44	—
Cheese, whole milk.	15	1.67	1.08	.45	.59	.04
Smoked herring.	06	4.17	1.21	.84	.37	—
Pork, salted, fat.	.16	1.56	1.23	.04	1.19	—
Pork, salted, fat.	12	2.08	1.65	.06	1.59	—
Cheese, skim milk.	.08	3.13	1.09	1.20	.21	.28
Wheat bread.	.08	3.13	2.08	.28	.06	1.74
Wheat bread.	06	4.17	2.75	.37	.07	2.31
Potatoes, $1.00 per. bushel.	01.7	3 24	3.04	.27	.03	2.74
Beans, 10 cts. per. quart.	05	5 00	3.96	1.16	.11	2.69
Potatoes, 75 cts. per bushel.	01.25	18.00	4 13	.36	.04	3.73
Wheat bread.	04	6.25	4.15	.56	.12	3.47
Oatmeal.	05	5.00	4.48	.76	.36	3.36
Wheat flour.	04.5	5.55	4.83	.62	.06	4.15
Wheat flour.	04	6.25	5.44	.69	.04	4.71
Potatoes, 50cts. per bushel.	00.83	26.47	6.06	.53	.05	5.48
Indian meal.	03	8.33	6.60	.70	.29	5.91

The methods of computing the cost of protein and the amounts obtained for twenty-five cents in different foods are as follows.

1. *Cost of protein.*—Suppose we wish to learn the costs of the nutrients in wheat flour, containing 11.1 per cent of protein, 1.1 per cent of fat, and 75.4 per cent of carbohydrates, and costing four cents a pound.

Let x represent the cost of a pound of carbohydrates in cents. Then, by the ratio of costs assumed above, a pound of fats would cost $3x$ cents and a pound of protein $5x$ cents. 100 pounds of the flour will cost 400 cents and will contain 11.1 pounds of protein, 1.1 pounds of fats, and 75.4 pounds of carbohydrates. We shall have

$75.4x$ cts.	=	cost of	75.4	pounds of	carbohydrates.
$3.3x$ "	=	" "	1.1	"	" fats.
$55.5x$ "	=	" "	11.1	"	" protein.
Total $134.2x$ "	=	" "	100	"	" flour = 400 cents.

Whence $x = 3$ cts. cost of carbohydrates per lb.
$3x = 9$ " " " fats per lb.
$5x = 15$ " " " protein per lb.

2. *Amounts of nutrients obtained for 25 cents.*—At 4 cents per pound for the flour, 25 cents will pay for 6.25 pounds. By the percentage composition above given 6.25 pounds of flour will contain .69 pound of protein, .07 pound of fats and 4.71 pounds of carbohydrates which are the amounts of nutrients obtained for 25 cents.

CONCLUSIONS.

The facts to which I have referred and others, which this is not the place to dwell upon in detail, seem to me to warrant the following statements.

1. The subject is one of the utmost importance. If, as you say, for the large majority of people, "half the struggle of life is a struggle for food,"— and I believe that your own statistics as well as those of Colonel Wright for this country, and those of Dr. Engel for Germany show that the statement is none too strong,— it is certainly worth while that people should know of what their food consists and how to economize it.

2. In order that ordinary people may know these things, it is necessary first of all that the facts should be found out. Here, as in many other arts and economies of life, the practical details which are at once most important and seemingly the most simple, rest upon data so extended and laws so abstruse as to be found out only by the longest inquiry and most profound research. It is only lately that science has begun to bring the most useful results, and hence we are just at the beginning of our knowledge of

these matters, yet enough has been done to give us a great deal of extremely useful information, and to show us where and how we must search for more.

3. Economy of food must be regarded from two standpoints :— (1) physiological and (2) pecuniary.

Viewed from the physiological standpoint, the facts at hand make it reasonably certain that many people in our country, including not simply the wealthy but those in what we call moderate circumstances as well, consume much more food than their bodies demand, and that the excess is detrimental, not only to their purses but, what is worse, to their health. The chief error seems to be in the excessive use of meat and other animal foods, though I am inclined to think that sweetmeats are also consumed to a very detrimental excess. The poor, too, whom poverty debars from overeating suffer, not only because of insufficient food, but because the food they do have is not that which is best adapted to their wants.

Viewed from the pecuniary standpoint, the data at hand indicate a great deal of bad economy, in the purchase of excess of food. This manifests itself in two ways: one is consumption of unnecessarily large quantities of food to which I have just referred. Of the many ways in which American wastefulness manifests itself, one of the chief, I believe, is in the waste of food. It is indeed better that part of the excess we purchase should be thrown away, than that it should all be employed in overloading our stomachs, but it would be better to purchase only so much as we need and use that rightly. And it is not the well-to-do only, but people in moderate circumstances, mechanics, farmers, tradesmen, professional men with limited incomes, among whom this wastefulness is very common.

The other kind of bad economy is in the use of needlessly expensive foods. Among that large class of people whose incomes are moderate, and intelligence and desire to economize considerable, a great deal is lost in the purchase of materials which supply the needed nutritious materials at high cost instead of those which would furnish them in equally wholesome and nutritious forms for less. Many a thrifty house pays from half a dollar to a dollar and a half a pound for the protein of the food on her table when she might obtain it in equally nutritious and wholesome forms for from twelve to forty cents.

But what seems to me the most pathetic part of the whole problem is, that it is the needy who know least how to make good use of what they have. It is too often the poor man's money that is wasted in the market and it is the food of the destitute that loses most from improper preparation. Here it is especially true that "to him that hath shall be given and from him that hath not shall be taken even that which he hath."

4. It is as important that the information should be spread as that it should be gained. There is a great dearth of reliable literature on this subject. This is due mainly to its newness. It is only within a few years that the data have accumulated of such amount and reliability that the authors of standard works have felt like incorporating them in their treatises. The army of ordinary writers, therefore, have never had the facts before them. The text books have had but little to say upon the subject, while the magazines and newspapers have contained a great deal that might better have been left unwritten. But treatises are already appearing in foreign languages, and must soon be written in English.

I think that the literature of the subject needs three things.

First: standard treatises giving the results of investigations to date.

Second: smaller works with the main results epitomized in form convenient for those especially interested in the matter to read.

Third: tracts for the people in which the most useful practical facts shall be set forth in plain and simple language illustrated by diagrams and enforced by practical applications which ordinary people may comprehend and use.

And finally, let me repeat, for this, I believe, is the most important thing of all for us to consider now,—we need more research. Almost nothing has been done on this side of the Atlantic. Nearly all the analyses we have of American food-materials except cereal grains and milk have been made within a short time in a single chemical laboratory. The most valuable part of our information comes from Germany. But, although the laws of nutrition are the same there as here, they are at best but imperfectly investigated. The pressing need is for more knowledge. The most successful research, that of the highest type, must be carried on here, as in Europe, in connection with the higher educational institutions.

But such research is costly and our universities and colleges have not the means for prosecuting it. Science in this country depends mainly upon private munificence for its advancement. The cost of a single pleasure yacht, if devoted to research in this direction, would not only give the donor fame, but would bring tenfold return in the benefits it would confer.

W. O. A.

APPENDIX.

The following data will in some measure justify the statements which I have given in my address, both in regard to the gain of the people of the United States in realized wealth, but also in respect to the increase of products which make for the common welfare.

Statistics of realized wealth, when given in terms of money, are delusive and uncertain, and such aggregates are of little value; but there are certain standards which may be taken as indications of the progress of accumulation or of the increased quantities of merchandise on the way from producer to consumer.

The data of insurance against loss by fire are capable of very accurate compilation from the official statements which are required by law.

One of the most valuable compilations of this sort appeared in the Insurance Monitor of New York, for September, 1884, made by the editor C. C. Hine, Esq.

The progressive increase in the amount of insurance against loss by fire since 1865—the figures indicating millions of dollars—is as follows:—

1865	$ 2564	1875	$ 6039
1866	2945	1876	5914
1867	3165	1877	6008
1868	3420	1878	6229
1869	3778	1879	6673
1870	4035	1880	7184
1871	3987	1881	7949
1872	4529	1882	8534
1873	5783	1883	9359
1874	5889		

The grain crop of 1865, including maize, wheat, oats, rye, barley and buckwheat amounted to 1,127,499,187 bushels; the crop of 1884 numbered 2,981,920, 332 bushels; the crop of 1885, in which the excess of corn will make up for the deficiency of wheat, will probably exceed 3,000,000,000 bushels. Except for the consolidation and extension of the railway service, and the very great reduction in the freight charge, these crops could not have been moved.

The number of miles of railroad Jan. 1, 1865, was 33,908; Jan. 1, 1885, it was 125,379. One-half the tonnage carried by these railways consists of food for man or beast.

If we compare the average charge per ton, per mile, as it was in 1865–1869, inclusive, with the average charge of each subsequent year, the difference on the traffic of each subsequent year assessed on the tonnage of that year amounts to a sum more than equal to the money expended on all the new railroads of that year.

The average product of pig iron for 1865–66–67 was 1,247,850 net tons; for 1882–83–84, a fraction, only, under 5,000,000 net tons each year.

The cotton crop of 1865–66, 1866–67, 1867–68 averaged 2,600,000 bales each year. The crops of 1882–83, 1883–84, 1884–85 averaged 6,122,000 bales each year. The present crop may exceed 7,000,000 bales.

The last 20 crops of slave-grown cotton numbered 56,757,906 bales. The last 20 crops of free-grown cotton numbered 86,829,795 bales; a gain of 30,031,889 bales, or 1,500,000 bales per year, besides an increase in the average weight per bale of about ten per cent; 400 lbs. in 1841, 485 lbs. in 1885. This difference, with the value of the seed now saved, but formerly wasted, may be computed at a value of about $1,800,000,000.

The debt of the United States at its maximum in 1865 amounted to $2,997,386,203, according to the estimate of Sec'y McCulloch, who added to the recorded debt, the sum due and in arrears for the pay of the army and on war contracts. On the 1st of August, 1885 the net debt amounted to $1,386,555,527.

Our population in 1865 was about 35,000,000; it is now over 57,000,000. The debt per capita in 1865 was over $84. It is now less than $24.

The debt of all Europe in 1884 as reported by M. G. Mulhall at

the meeting of the British Association in Montreal was $21,319,-620,000. Omitting Russia, Turkey, Servia and the bankrupt states of Spain and Portugal, there remains over $15,000,000,000 of debt due by England, Germany, France and other states which are assumed to be solvent. The population of these latter states is now about 200,000,000 and the proportion of their steadily increasing debt is $75 per head. These states have one mile of railroad to each 2420 persons. In the United States there is one mile to each 450 persons.

The number of men in actual service in the standing armies of Europe, omitting Russia and Turkey, as listed in Martius' Year Book for 1884 was 2,675,386 or one in every twenty-one and a half of the adult men, assuming one in four of the population as such.

The number in the army and navy of the United States is 36,871 or one in three hundred and eighty-five.

The number of men in the reserves in Europe, who are enrolled and subject to active service at a moment's notice, is far greater than the number actually under arms. If to the waste of time of those who are under arms be added the cost of their support, at least ten per cent of the productive power of Europe is spent in passive war even in periods of so-called peace while a large part of the remaining product is distributed according to privilege rather than according to service. These conditions are as impossible of continuance as they are dangerous in their existence.

I may safely leave you to make the application of these facts to the relative conditions of this country and of Europe—in sadness rather than in exultation.

At the beginning of the next century this country will be free from debt—our army will have become a mere national police—the progress of invention will have rendered navies powerless either for offence or defence.

We are to be tried by the fire of prosperity and tested by the dangers of luxury. The burning question now is, Are we capable of maintaining a just government in its integrity?

"Of what avail, the plough or sail,
Or land, or life, if freedom fail!"

E. A.

PAPERS READ.

On the need of a systematic reorganization of the executive service of the United States, in the interest of public economy and of science. By John W. Hoyt, LL.D., Cheyenne, W. T.

[ABSTRACT.[1]]

Had the executive branch of the federal government remained without change of organization for a century, it may be assumed that the natural disinclination of most men to disturb the existing order of things would now render the effort to secure important modifications of it at once laborious and of doubtful issue. But such is not the state of the case. So far from having remained in *statu quo* for the hundred years of our national life, the constitution of the executive service has already undergone repeated and important changes. It has had a continuous growth,—slower, naturally, than the interests of the country have demanded, and, in so far as departmental divisions of it are concerned, of necessity unequal.

The beginning was with but three departments: of State, of the Treasury, and of War; the last-named embracing what is now the Navy Department during the first decade of our national history.

There was a postmaster general from the start, but his office was deemed of secondary importance and he had no place in the cabinet until 1829.

There was no Interior Department, for at first there was but little for such a department to represent. But by the year 1847, through the acquisition of new territory and an extraordinary national development, there had come the realization of the need of a new department, that should be charged with the supervision of certain growing interests that could not properly be assigned to either of the existing departments, namely, the management of the vast public domain, the issue of patents, etc. And so Congress created the new Department of the Interior, to have charge

[1] This paper is published without being revised by the author.—Editor.

of these and such other domestic interests as should require governmental supervision.

For more than three-quarters of a century, there was no Department of Justice; for the legal business of the government was at first so limited that it was easily transacted by the attorney-general and a small force of subordinates. He had a seat in the cabinet from the beginning, but was simply legal advisor of the president and the nation's attorney. It was not till after the great civil war, that the present administrative department was organized.

There was for a long period no recognition whatever of any of the national industries as needing governmental supervision. Agriculture, from time immemorial, had been conducted in a rude, empirical manner and practically speaking other industries were yet in embryo.

But, behold, what marvellous changes have come with the geographical enlargement. We are now nearly sixty millions of people, with a property valuation approaching fifty thousand million dollars. The genius and energy of Americans have been directed to a multitude of new industries, and the sciences have become the practical servitors of mankind.

Growth like this has, of course, necessitated a large increase in the amount of the civil service to be performed, and created an imperative demand for corresponding improvement and enlargement of that grand system of agencies by which the executive branch of the service is conducted.

That the present organization of bureaus and special services is exceedingly faulty is too evident to require more than a pointing out of the illogical groupings of them and the growing inequality of the burdens and responsibilities thereby imposed, for the heads of some of the departments have comparatively light work, while others are greatly overburdened. Moreover, the fields covered by the Treasury and the Interior are so vast, and so various in the nature of the subjects embraced, that it is no longer possible that they should be administered with that wisdom and thoroughness which the public welfare demands.

Thus, in addition to the duties necessarily devolved upon the secretary of the treasury, which are various and difficult enough to fully engage the powers of any statesman, as well as burdensome enough in their exactions to occupy his entire time and energies

many others are imposed by the present makeshift distribution of which he should be relieved.

The bureau of the coast and geodetic surveys, the supervision of the construction of public buildings, the bureau of statistics, and perhaps yet others, could be dissevered from the Treasury Department without the slightest difficulty and with great positive advantage.

The same is true of the Interior. Think of our departmental supervision of the vast and dissimilar fields covered by the general land office; the bureau of Indian affairs, with its knotty problems for practical solution; the bureau of pensions, with its annual disbursements of many millions; the patent office, with its difficult questions and numerous appeals; the bureau of education, with its world-wide field of investigation and its practical mission of incalculable importance; that interesting and valuable work known as the United States geological survey; the railway commission formed for the protection of the government's interest in the Pacific railways; the supervision of the charitable institutions of the government in the District of Columbia and elsewhere, and finally the general oversight of nine immense territories, and then marvel at the serious mistakes sometimes made, or that the great interests embraced constantly suffer yet more important negative loss through want of the utmost thoroughness in management.

Again, the incongruity of the subjects embraced in these two great departments is scarcely less obnoxious to criticism than are their number and magnitude. All things are related to each other in some manner, but there is nevertheless a fitness of association and an unfitness. And certainly there is no very marked congruity between patents and geological surveys, the guidance of the nation's educational forces and the control of its savage tribes, the survey and sale of the public lands and the oversight of charitable institutions, the payment of pensions, the adjustment of railway accounts and the supervision of the territorial governments. Yet such is the aggregation of mismatched burdens under which the Secretary of the Interior is now heroically—he will pardon me for saying almost hopelessly—struggling.

After this rapid survey it will be manifest that redistribution would not alone be a sufficient remedy. It is not even practicable to any considerable extent: there are too many responsibilities of

superintendence in the civil division of the executive service for the very few ministers to whom they must needs be assigned. Not even the lesser countries of the old world have found it practicable to administer their public affairs with so small a circle of ministers, and the extent to which services of various kinds have grown up in our own country outside of the departments, simply because it was found to be impracticable to lay further responsibilities upon the present cabinet officers, of itself constitutes an admission of the need herein urged of a reorganization by increase of competent supervision, as well as by systematic coördination.

A still further reason is furnished by the important fact that, even with our past unprecedented growth as a nation, we seem ever entering upon a new era of yet more marvellous development; so that if such reorganizations were not pressingly needed to-day it would be to-morrow. The progress of our country and age refuses further postponement or the use of temporary expedients. The necessities of the service require the immediate enlargement of one existing department and the creation of one new department as conditions of a thorough administration of the national affairs. The industrial forces of the country, although so rapidly strengthening, would acquire yet greater efficiency if marshalled and directed with the utmost possible skill, and the important scientific agencies already at work by congressional authority, and which, during the past quarter of a century have at once contributed much to the growth of our industries and to the advancement of science, would become still more useful and successful if moving in full harmony and efficiency under one directing head.

I am not unmindful that a congressional commission, formed by able statesmen, to consider and recommend a measure for the most advantageous association of the various scientific organizations of the government, is now at work upon this problem; that the National Academy of Sciences has recommended to this commission a definite measure of this sort, to wit, "the organization of a permanent commission to prescribe a general policy for each of these bureaus"—such commission to be composed of a secretary of one of the departments of the government, the president of the National Academy of Sciences, the heads of the scientific bureaus embraced, a professor of mathematics from the Naval Observatory, an officer of the Engineer Corps, and two citizens of the United States, eminent as scientific men, to be appointed by the President,

and that very able gentlemen who have given much thought to this subject, and who deeply realize its importance, including especially the learned Director of the Geological Survey of the United States, have reached yet other conclusions as to the best means of accomplishing the desired objects. But I do not find in these recommendations anything to essentially modify the views herein presented—views fully outlined several years ago, while the writer was engaged at Washington upon a critical study of the civil service, and since only strengthened by further observation and reflection. In other words I find in none of them the statement of any fact or principle essentially opposed to the more national, simple and historical way of meeting this case by placing all those organizations under one ministerial head.

All other methods are certainly open to serious objections besides the capital one of divided responsibility, and appear to have been offered rather as a temporary expedient, a compromise between what is and what should be, on account of doubts whether Congress could be induced to undertake at once, what so manifestly needs to be done.

A coördination of the scientific bureaus and commissions and their supervision by a mixed commission as proposed by the National Academy, or by the Regents of the Smithsonian Institution, led by the very able and eminent executive officer of that noble organization, as suggested by the distinguished Director of the U. S. Geological Survey, might well be an improvement upon the present order of things, in which there is sometimes needless duplication of work; in which work may be undertaken by one that could be better done by another, and in which all are comparable rather to scattered bands of scouts and skirmishers, each fighting in its own way, rather than to a great and thoroughly organized army moving in full harmony and efficiency under one commanding general. But a great nation should legislate, not with reference to special circumstances of the hour, or the present possible availability of an exceptional man; it should rather broadly plan and courageously act upon just general principles and for all time.

And why organize the scientific forces outside of the departments of the government? Why refuse to science and education, those foremost factors in the national security, prosperity and future glory, the dignity of ministerial rank, and the added strength and influence that would attach to the seal of a great department?

In the old world their interests are accorded honors and prerogatives equal to those accorded to war, and that even by the warlike powers; and shall not America, whose mission it is to give to her people the highest intelligence, the freest and best individual development and the utmost material prosperity, as well as to promote the ascendency of peace and to lead all the nations in the grand march of civilization—shall not this great republic, still maintaining two full departments for Mars, at last in like manner exalt Minerva and clothe her with the dignity of fullest honors and the majesty of highest powers.

The secretary of the Department of Science and Education would unquestionably be a man of acknowledged scientific attainments, as well as of administrative ability, and he would be supported by a board of councillors, the heads of bureaus, whose tried wisdom and large experience would properly reënforce his own. There would indeed be the bare possibility of an occasional arbitrary change of men, a non-political and scientific minister; but in the absence of political reasons and with the growing sentiment that will soon come to enforce a reasonable permanency of specially qualified and faithful non-political public servants, it may be assumed that such changes would be of rarest occurrence, except for cause. And as for the subordinates in such a department, being universally recognized as *experts*, under proper civil service regulations, they would have not only just immunity from removal, but would have opened to them a *career* through the agency of a just system of promotions for merit.

Being further strengthened, as it surely would be by the friendly coöperation and encouragement of university, college and private workers in every branch of science, who can foretell the power that such a department, so organized and so administered, would become for the advancement of science and the furtherance of all the great interests of the nation? Every other department would appeal to it for information and Congress would refer to it difficult questions requiring a profound knowledge of science for their solution. It might, indeed, at length become a supreme example and authority for the civilized world.

As for education, it would find itself reinforced by a legal association with general science and prove itself yet more efficient than in its present incongruous relationship with interests wholly foreign. The noble work, the present bureau of education has done

and is doing, fully justifies the claim now made in its behalf that it be thus further honored and empowered.

In view of all these considerations, I assume that a full investigation of the subject of this paper would lead to the following departmental changes, to wit:

1. The expansion of the present quasi department of agriculture into a full department of industry and commerce, with bureaus of agriculture, of animal industries, including fisheries, of the mechanical industries, including mining, of commerce, and of industrial statistics.

2. The separation from existing departments of all such bureaus and commissions not essentially belonging to them, as should be embraced in a department of science and education, to wit: The bureau of the coast and geodetical surveys; the bureau of the geological and topographical surveys; the bureau of meteorology, including the present bureau of signal service; the national observatories, astronomical, magnetic and electric, and the national museums, with ministerial supervision of all charitable institutions of the government, not essentially connected with other departments; a bureau of public works; a bureau of economical investigation for inquiries into questions of labor, subsistence and public health; the bureau of education, with inspection of all schools endowed by the government other than the military and naval academies; and the national library.

3. The further equalization of executive responsibilities by the transfer of the Indian Bureau to the War Department, where, at least in the present condition of the Indians, that bureau more properly belongs, and where its affairs could be more economically, if not better managed than under the Interior.

A systematic organization of the executive departments like that proposed would unquestionably increase their efficiency; while the union of existing educational and scientific bureaus under one minister, and the creation *de novo* of bureaus of commerce and of the mechanical industries, in connection with the agricultural bureau, as constituents of one administrative department would meet important demands long made upon the country and now certain to be made with increased earnestness. The changes proposed would add a few thousand dollars, and only a few, to the present accounted cost of carrying on the government; but they would insure a service so much better as to repay that extra

cost many fold, besides at last making deserved recognition of important industrial scientific and educational interests hitherto either wholly or in part neglected, as well to their injury as to the disadvantage and discredit of the nation.

RELATIVE VALUES OF HUMAN FOODS. By Maj. HENRY E. ALVORD, Houghton Farm, Mountainville, New York, N. Y.

[ABSTRACT.]

THERE are different ways of comparing human foods upon the score of economy. If one attempts to consider at once their digestibility, chemical composition and usual cost, besides other conditions which should not be ignored, the problem becomes very complex. It is hard to define the average human stomach, and we are so much in the dark on the questions of actual proportions of digestibility in different forms of food, that it is safer to drop this factor than to include it. Chemical knowledge of foods and their market prices, are sufficient, when combined, to form an interesting study.

The basis selected for comparison is all-important. A casual observation shows the necessity of separating foods into two grand divisions, animal and vegetable, and of selecting a basis for each.

If any food could be found in common use, at a fairly steady price and useful only for its protein, the direct value or cost of protein could be determined. This being impracticable, a standard food, like average ox-beef, flesh free from bone, may be taken and the cost of protein obtained by difference. We will assume that the fats of average beef and pure lard are equivalent in nutrition and wholly digestible, and take lard at 12 cents per pound as the safest base for animal foods. In average ox-beef there are 5.2 per cent of fats and 23.4 per cent of protein. Placing such beef at 16 cts. per pound, the account will stand thus per hundredweight:

100 lbs.	beef		$ 16.00
5.2 "	fat		.624
21.4 "	protein		15.376

From these figures are obtained the cost of nutrients in animal foods, viz. :—protein, 72 cts. pr. lb. ; fats, 12 cts. ; carbohydrates, 7 cts.

The old German ratio of carbohydrates and fats of 1 : 2.5 so largely adopted in this country was never fully accepted and later investigations show its inaccuracy. We are well supported in substituting 1 : 1.75. Therefore to get carbohydrates from fats, deduct 43 per cent from the latter.

For vegetable foods, the potato is unquestionably the best basis, and the price per bushel is taken at 60 cts. or $1.00 per cwt. Four cents is assigned as the value of the unextracted starch and the other carbohydrates, and by a calculation analogous to that for beef, potatoes being rated as about 20 per cent carbohydrates, the value of nutritious matter in vegetable foods is fixed thus:

Protein, 10 cts. per lb. ; carbohydrates, 4 cts. per lb.

Based upon these values, the following table has been compiled.

It gives the chief nutrients, the value and average price, approximately, of 100 pounds of thirty common articles of food, half animal and half vegetable. The fats are included in the column headed carbohydrates. A column is added at the right indicating by the signs, plus and minus, whether the usual selling price, as stated, is more or less than the food value, computed as above.

[See Table on next page.]

The figures for the chemical composition of the foods named are taken from such authority (see appended Note) that they can hardly be questioned. If exceptions are taken to the assumed prices of the basic articles, it is manifest that by a simple calculation based upon actually existing market rates, the columns of food values may be easily reconstructed to suit any given locality.

The column of average market price is simply for illustration and will vary with time and place.

This inquiry into the relative value of human foods was instituted for the purpose of making an accurate economic comparison between the different products of the dairy and between those and standard articles of diet. Attention is invited to these facts, as exhibited by the table.

COMPOSITION AND VALUE OF FOODS.

PER ONE HUNDRED POUNDS.						Price g'tr + or less — than value =
NAME.	Protein.	Carbo-Hydrates	Value.	Average Market Price.		
Standard Cows' Milk	4 00	10 52	$3 54	$3 25	a	—
Cows' Milk (average all kinds)	3 41	11 23	3 24	2 79	b	—
Skimmed Milk	3 06	6 15	2 63	1 77	c	—
Butter-milk	3 78	5 89	3 13	1 77	d	—
Cream	3 70	48 51	6 06	12 50		+
Butter	0 86	146 05	10 67	25 00		+
Fat Cheese	27 16	55 78	23 46	14 00		—
Average Ox Beef	21 39	9 08	16 32	16 32		=
Fat Veal	18 88	13 89	14 57	15 00		+
Fat Mutton	14 80	63 73	15 12	15 00		—
Fat Pork	14 54	65 35	15 04	13 00		—
Domestic Fowl (fat)	18 49	17 54	14 54	16 00		+
Hens' Eggs	12 55	21 74	10 56	10 65	e	+
Salmon	13 10	12 67	10 32	30 00		+
Mackerel	23 42	11 83	17 69	10 00		—
Cod Fish (dried)	17 90	2 25	13 05	8 00		—
Oysters	4 95	3 27	3 97	10 00		+
Fine Wheat Flour	8 91	76 12	3 94	3 00		—
Fine Wheat Bread	6 82	53 69	2 83	4 00		+
Oat Meal	15 50	74 37	4 52	3 00		—
Potatoes	1 79	20 84	1 01	1 00		=
Rice	1 81	76 61	3 24	6 00		+
Beans	23 56	52 10	4 44	4 00		—
Pease	22 63	56 25	4 51	5 00		+
Cabbage	2 95	9 24	0 66	1 00		+
Onions (red)	1 68	10 90	0 61	2 00		+
Tomatoes	1 25	4 66	0 31	2 00		+
Cane Sugar	0 35	96 73	3 90	6 00		+
Honey	1 29	81 43	3 39	25 00		+
Apples	0 39	13 74	0 59			+
Peaches	0 65	12 57	0 57			+
Grapes	0 59	17 11	0 74			+
Strawberries	1 07	8 48	0 45			+
Dried Apples	1 06	55 97	2 35			+

Notes:—a, 7c. per qt.; b, 6c. per qt.; c, 4c. per qt.; d, 4c. per qt.; e, 10c. per doz.

Skim-milk, butter-milk and cheese at their usual retail prices, are cheaper as nutritious food than any other articles on the list, and are approached in this respect only by fresh mackerel and dried cod-fish. On the contrary, butter costs two or three times its real food value, and often more. What shall be said of domestic economy in America, where more butter and less cheese are consumed per capita than in any other nation in our zone? And of the government of some our great cities where Boards of Health absolutely prohibit the sale of skimmed milk and actually destroy all that can be found? Of butchers' meats, pork and mutton are the cheapest and veal the dearest. Of fish, mackerel is the cheapest while salmon and oysters are about as dear relatively as butter.

Eggs generally sell at their full food value. Wheat-flour, oatmeal and beans are the cheapest forms of vegetable food, nearly all other vegetables (except potatoes) as well as the fruits, costing more than they are worth for their nutritive properties alone.

GENERAL NOTE: Additional Tables have been prepared to accompany the foregoing on the same plan, but with several additional columns for chemical composition, embracing also every known article of human food. As illustrating their completeness, this classified summary is given: flesh, 19 articles; fish, 14 articles; fowl, eggs and game, 12 articles; dairy products, 18 articles; cereals and legumes, 10 articles; flour, meal, bread, etc., 17 articles; vegetables, 20 articles; fruits, 20 articles, and sweets 5 articles: in all 135 articles. To these have been added a Table, giving the amounts, composition and nutritive ratio of food actually consumed by persons of different ages and in varied occupations, as observed in 52 individuals. All these Tables are compilations only and are mainly translated from the work of Dr. J. Koenig entitled Zusammensetzung der menschlichen Nahrungs und Genusmittel.

Dr. Koenig collected his analyses from the best chemists, naming his authorities, and in most cases gives the mean of a number of analyses, — as for example, 37 for beef, 184 for wheat, 70 for potatoes, 57 for sugar, 17 for apples, 89 for butter, 100 for cheese and 339 for milk. The labor of translation, with the recalculation of weights, values, etc., and careful verification, has been performed by Mr. F. E. Emery, B.S., of Maine, my principal assistant in the Experiment Department of Houghton Farm.

COMPOSITION AND VALUE OF FOODS.

NAME.	PER CENT BUYABLE FOODS. Protein.	Fuel-value Heat-units	Value.	Average Market Price		Price gr'r + or less — than value =
Standard Cows' Milk	4 00	20 32	$3 54	$2 25	a	—
Cows' Milk, average all kinds	3 41	11 23	3 24	2 79	b	—
Skimmed Milk	3 06	6 15	2 63	1 77	c	—
Butter-milk	3 79	5 39	3 13	1 77	d	—
Cream	3 78	48 51	6 66	12 50		+
Butter	0 86	106 06	10 67	25 00		+
Fat Cheese	27 16	55 79	23 46	14 00		—
Average Ox Beef	21 39	9 08	16 32	16 32		=
Fat Veal	18 94	13 89	14 57	15 00		+
Fat Mutton	14 80	63 73	15 12	15 00		—
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Oat Meal	15 50	74 37	4 52	3 00		—
Potatoes	1 79	20 84	1 01	1 00		=
Rice	1 81	75 61	3 24	6 00		+
Beans	23 56	52 10	4 44	4 00		—
Pease	22 63	56 25	4 51	5 00		+
Cabbage	2 95	9 24	0 66	1 00		+
Onions (red)	1 68	10 99	0 61	2 00		+
Tomatoes	1 25	4 66	0 31	2 00		+
Cane Sugar	0 35	96 73	3 90	6 00		+
Honey	1 29	81 43	3 39	25 00		+
Apples	0 39	13 74	0 59			+
Peaches	0 65	12 57	0 57			+
Grapes	0 59	17 11	0 71			+
Strawberries	1 07	8 48	0 45			+
Dried Apples	1 06	55 97	2 35			+

Notes:—a, 7c. per qt.; b, 6c. per qt.; c, 4c. per qt.; d, 4c. per qt.; e, 16c. per doz.

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AN ILLUSTRATION OF A METHOD OF TEACHING ELEMENTARY SCIENCE IN GRAMMAR SCHOOLS. By Prof. ELLEN H. RICHARDS, Massachusetts Institute of Technology, Boston, Mass.

THE subject was minerals, their composition and physical characteristics. Each child had the specimen in hand. The intention was to show that simple elementary principles may be grasped by children of ten to twelve years of age and that it is easier for them than for older pupils.

CITY GOVERNMENT. By C. RAEMELIN, Dent, Cincinnati, Ohio.

[Summary of paper.]

QUESTION of great importance, especially in the United States. Party misgovernment exists in the place of right government. Turn intuitively to ancient cities for comparative inquiry. Old history is city history.

City government in the *middle ages* in Germany, Italy, Netherlands, Great Britain. Colonial city government.

City government in *modern Europe:* France, Germany, Great Britain, Spain, Austria, Hungary.

City government in *modern America.* The indifference and ill will of the framers of American government to cities. John Adams, Thomas Jefferson, and Andrew Jackson's remarks. The surrender of constitutional government to party government. Its fatal results.

Remedy lies chiefly in constitutional reform. Cities must be integral constitutional elements, and so named in constitutions. Must not be open to arbitrary legislative changes. State government must not interfere beyond general supervision and it must be rather executive, administrative and disciplinary, than legislative or judicial. There should be also a national city council for unification of city government and the laws thereon. Cities must attain their national standing. Every city is of importance to

more than one state. Therefore, city laws and city government must be guaranteed against the arbitrary legislation of one state.

Conclusion. City government needs readjustment in all its relations to other bodies politic. City government must be reconstructed on the unit basis. Unity of government, unity in administration, unity in finance, unity in conducting it on the highest ideal state reason.

THE SCIENCE OF STATISTICAL ANALYSIS. By CHARLES S. HILL, State Department, Washington, D. C.

THE Sciences are becoming, as they should be, the feature of education. Not that the classics must go, but that the sciences must come; between these two classes in our colleges, and in our social and public relations, there is at present an evidence of feeling akin more to bitterness than to reason.

The classic scholar has for so long a period ignored the greater importance and classification of scientific branches of knowledge that the modesty of the student, seeking skilfully the development of practical industry at home, and commercial relations with foreign countries, has unjustly and injuriously kept back much benefit to the masses of mankind and rational principles of reason.

The beautiful accomplishment of a proficiency in interchanging thought and salutation in a common language gives grace, ease, and elegance to intercourse in society, in travelling, in diplomacy, and in many associations, as well as in study, but it is likewise a burden if allowed to obstruct the progress of industry.

It is in the education of the masses that the power of a nation lies; that the light of knowledge burns brightest and incessantly for the benefit of mankind.

And even in the gradual advance of science to the foremost rank of study there has been too much disposition to disregard the many distinctive branches, and particularly the very rudiments of this standard of knowledge, even as the classic scholar has dis-

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regarded the multiplicity, and often the most important base, of languages.

Content with the acquirement of a science, the student often glories in the knowledge of a principle without according his knowledge to the scientific system of research through the labyrinths of natural matter and analysis of statistical data by means of which knowledge is attained, and in many instances, it must be said with regret, without a willingness even to acknowledge that the system of analysis is a distinct and most important science—much less the rudiment of all sciences!

The science of statistical analysis is paramount in the importance of correctness of result and satisfactory comprehension of how that result can be verified. The analysis of official statistical data is mining in mountains of precious metals — a miner's labor in separating the gold from the sulphurets.

The labor of such work is purely and indisputably a science of the highest order. To separate and group together the figures and facts of greatest value, exhibiting and analyzing the wealth of hidden knowledge, and interweaving chains of social problems with golden truths—otherwise left buried from view—which glisten the brighter when contrasted with the brassy alloys of sophistry or the counterfeit representations of fallacy, is a science without a peer.

The definition of science, says Professor Fowler, of Oxford, "is the filiation of causes through the common observation to things beyond."

Accepting the expression of Professor Fowler, we must accept, as the corner-stone of all sciences, arithmetic, the only basis upon which we may, with that second stone of science, logic, found an article on political economy, which, as a knowledge, is far more powerful in influence, effective in application, and brilliant as well as bountiful in results.

To be thus effectual and bountiful in results, delicate distinction between like and unlike conditions is essential; *similia similibus curantur* is a faithful precept; but the application of like doctrine to cure evil or to guide our course merely upon general principles is the most fatal error into which a people may fall especially in economics.

While the first object of the student is to find the origin of his subject, his great error, like that of some "professors" of *theo-*

retical economy, is in applying the derivations of terms to their reasoning rather than in pursuing the pure science of defining the cause that must work the results.

But neither science, arithmetic nor logic, can produce food or the other necessaries of life; it requires good sense and reason which practical experience alone can give, to apply rules or principles to trading and economy.

To draw these thoroughly into harmonious unity of action in our individual daily life is not only advisable, but essential to our prosperity, and, therefore, we must look particularly into the causes which create results rather than into the etymology of words or rules of syntax, and not forget to reason upon science with

> "Good sense, which is alone the gift of Heaven,
> And—though no science—fairly worth the seven."

Statistical science, applied to social phenomena, enables us to comprehend facts which to the unthinking are incredible. One fact is worth one hundred theories. No greater misnomer can be applied to him who "has no time" for such data than the word "practical."

Nor should it be considered that the logic of statistics belongs alone to scientists. It is an essential in the education of every man who desires to arrange his study or regulate his own business correctly. It is as important to possess this safeguard or guide through the numerous channels of occupation in life as the chart is to guide the mariner through the entrance to his harbor.

How necessary, then, is the systematic preparation of official statistical data from all parts of the world, and how much more necessary that the analysis of such data should be made and issued authoritatively, that our manufacturers, merchants, and, indeed, our whole people, may be assured that the information they receive is not deceiving.

For more than a hundred years the Government of the United States failed to appreciate fully the Consul as a factor in the great work of protecting and enlarging the foreign commerce of the country.

And yet the principal idea held by the founders of our Republic, when creating the consular service, was the development of international trade through the medium of agents of the United States

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Strawberries	1 07	8 48	0 45			+
Dried Apples	1 06	55 97	2 35			+

Notes:—a, 7c. per qt.; b, 6c. per qt.; c, 4c. per qt.; d, 4c. per qt.; e, 16c. per doz.

ticularly from their old date, and from the natural absence of incentive to the consul, especially in the practical utility of his work or appreciation by the public, which always stimulates pride and correctness.

In the spring of 1880 the Department of State made strenuous efforts to remedy this evil and utilize this vast field of information by more frequent and *immediate* publication of special and selected reports, as referred to above, relating to every industry and every condition of other nations, whereby our own social and industrial conditions might be advanced.

To accomplish this work was at first a great difficulty, but finally, through earnest efforts and determination, the exhumation of the consul from obscurity to conspicuousness—his revival from inaction to usefulness—was effected through this channel of communication that enables him to show himself publicly according to his real merit, and serve his country practically.

Thus for about four years this system has been tried in a very small way. In this short time that department has daily received letters from scientists of all branches, from senators and members of Congress, from industrial, educational, and other corporate bodies, from private individuals, home and foreign, attesting the value of these publications, and requesting that more copies, if possible, be supplied; which request, however, has been only partially complied with out of the limited issue of 10,000 copies, 4,000 of which are supplied to Congress, and about 2,000 to consuls, an average of 10 each to the former and 3 each to the latter; the remainder being demanded by the press, merchants, and laboring masses.

When it is taken into consideration that every report, previous to publication, has to be copied, revised, condensed, often corrected, and sometimes rewritten, the labor incident thereto can be appreciated, and not even then to its full extent, save by men who have experience in the work of statistical analyses.

The scope of the field of information, as set forth in the requirements of consular regulations, 1881, article 27, paragraph 556, embraces the following industries, viz.:

1. Agriculture.
2. Manufactures.
3. Mining.

4. Fisheries.
5. Forestry.
6. Commerce and Navigation.
7. Revenues.
8. Miscellaneous, covering the conditions and peculiarities in business and habits of the several peoples of the world, viz., population, emigration, labor, wages, prices of food and living.

The last three Secretaries of State, Messrs. Evarts, Blaine and Frelinghuysen, under whose supervision and direction this labor has been performed, have fully appreciated these difficulties and have repeatedly called Congressional attention to the same and asked for sufficient provisions to enable that department to carry out this new system to its most profitable extent and in order to meet the petitions of the commercial community, made to the department, in this endeavor.

It is hardly possible to-day to meet and converse with a business or literary man from or in any city of our country who will not in some way speak of the benefit or pleasure he has derived from this systematic preparation and publication of official matter and data. Contrast the benefit of the system of education and scientific analysis with the circumscribed condition and narrow-mindedness of the classic Turkish Cadi, Imaum Ali Zadè, in reply to, and as given to the public by Mr. Layard, regarding the industry and commerce of Constantinople:

"The thing you ask of me is both difficult and useless. Although I have passed all my days in this place, I have neither counted the houses, nor have I inquired into the number of inhabitants; and as to what one person loads on his mules, and another stows away in the bottom of his ship, that is no business of mine. But, above all, as to the previous of this city, God only knows the amount of dirt and confusion that the infidels may have eaten before the coming of the sword of Islam. It were unprofitable for us to inquire into it. O my soul! O my lamb! seek not after the things which concern thee not. Thou camest unto us and we welcomed thee: go in peace."

Such contractedness of mind and illiberality are too apt to prevail even with a few nearer our own home, but as "the sciences must come," so will analysis of the several sciences from rudiment to maturity, and their results be properly and justly classified.

The science of statistics may be credited to Sir Wm. Petty, of England, as its founder about the year 1650, but was first systemized by Gottfried Achenwall, of Germany, a century later, who gave the name of Staat to his labor of love, and his noble purposes have been matured and wonderfully advanced by Quetelet, of Belgium; Engel, of Dresden; Rouher, of France; Bodio, of Italy; Neumann Spellart, of Austria; Giffin, Bourne, and Levi; Farr, of England; and their names will soon be "legion," and the world will be all the wiser for the work of those

> Statists, indeed!
> "And lovers of their country."

Germany and England were the primogenitors of this science, the great value of which is now being appreciated by the civilized world. Nothing could be more forcible, more beautiful, or more appropriate here than the words of the Prince Consort Albert in opening the statistical Congress in London in 1860:

> "Happy and proud indeed should I feel if this noble gathering should be enabled to lay the solid foundations of an edifice, *necessarily slow of construction*, and requiring for generations to come laborious and persevering exertions, intended as it is for the promotion of human happiness by leading to the discovery of those eternal laws upon which universal happiness is dependent."

These noble words are republican in sentiment, although born of a royal mind.

Is not, then, statistical analysis the foundation of every science, the development of all good, the exposition of all bad? and may we not hope for the sake of truth and practical usefulness and common sense, rather than theoretical sophistry, that this science may in our colleges and universities be particularly

> "Tutored in the rudiments
> Of many desperate studies?"

THE PRESENT STATUS AND FUTURE PROSPECTS OF SILK CULTURE IN THE UNITED STATES. By Prof. C. V. RILEY, U. S. Entomologist, Washington, D. C.

[ABSTRACT.]

THE subject is discussed under the following heads:

1. The adaptability of the United States to silk culture.
2. Silk culture in the Gulf States.
3. Silk culture on the Pacific Coast.
4. Profits of silk culture.
5. Necessity for a home market for the cocoons.
6. The prospects of establishing a market by private enterprise.
7. The practical outcome of the efforts of the Department of Agriculture in promoting silk culture under present restrictions.

The paper deals with the above-named subjects in detail and the essential conclusions are:

1. The adaptability of our country to silk culture is proven beyond all question.

2. That the profits are so small that by far the larger proportion of those who become interested abandon the culture after the first year.

3. That the present encouragement given by Congress through the Department of Agriculture has been productive of good in that it has enabled the establishment of three reeling centres, one at Philadelphia, one at New Orleans and one at San Francisco, which are in active operation and furnish a home market for the cocoons.

4. That there is great difficulty in carrying on the experiment on true business principles because of the law which prevents the Commissioner of Agriculture from selling the products of these reels and thus utilizing the income.

5. That this encouragement has intensified the interest felt in the subject, but that it can endure only so long as Congress chooses to continue the appropriation. This, once withdrawn, will precipitate a reaction.

6. Finally, that no permanent advantage can be secured until tariff legislation gives real encouragement to the industry and recognizes the fact that so-called "raw silk" is a manufactured article and should, if other manufactured articles are to be protected, receive like protection.

SOME DEFECTS OF OUR SAVINGS BANK SYSTEM, AND THE NEED OF POSTAL SAVINGS BANKS FOR THE UNITED STATES.

By CHAS. W. SMILEY, United States Fish Commission, Washington, D. C.

[ABSTRACT.]

THE savings banks are managed mostly by unpaid trustees who have shown that as a class they will not bestow the time and care necessary to protect the banks from dishonest officials and bad investments.

Savings banks, being designed as perfectly safe depositories with a low rate of interest and for the training of the very poor and very ignorant in thrift and economy, should not be subjected to any such possibilities of failure as beset the whole system.

When officers default or investments prove bad, there is no way to make good the loss unless sufficient profits have been withheld from dividends to meet the contingency. This means has often been inadequate.

When assets fall below liabilities even one per cent the danger of the worse evil of a receivership is at hand. The many years that impaired banks have been in receivers' hands and the enormous cost of receiverships, sometimes amounting to $100,000, have created great injury, loss of confidence and positive suffering.

The recently developed evil of scaling down the deposits has been invented to obviate the admitted crimes and outrages of receiverships. Though a less evil, its baneful effects are evident.

For a savings bank to invest in anything outside of U. S. bonds or the best state bonds is too risky to be indulged in. This is because a run is liable to occur at any time and its assets should always be convertible at will into cash. The owning of mortgages, real estate and other property which cannot be realized upon in time of a panic invites and feeds the flames of panic in the minds of ignorant men and helpless women. This kind of assets has been the occasion of receiverships and litigations drawn out through periods of five, ten and fifteen years.

A privately managed savings bank can never be free from runs and distrust however sound it may happen to be.

Trustees will not resist the temptation to compete with others in paying rates of interest and this instantly converts the banks from charitable institutions into commercial enterprises. Then the fundamental idea of encouraging thrift and economy through gratuitous aid rendered by trustees has been abandoned.

The salaried officials such as the treasurers command salaries somewhat proportioned to the amount of deposits. Hence their interest in getting large deposits through high rates of interest. But to do this, investments must be put into risky places. This evil is almost a necessity of the system.

The mania for ornamenting cities and towns with high-priced banking houses paid for out of the deposits of these widows and poor children and illiterates is widespread and besides being an object lesson the opposite of economy is financially unwise.

The amount of money needed to establish a private savings bank is such as to confine them to cities and large towns. They are thus accessible with difficulty or not at all to nine-tenths of the population of the U. S.

The banking hours are often very inconvenient for laboring people.

Postal Savings Banks were introduced into Great Britain in 1861, into Belgium in 1870, into the Netherlands in 1880, into Australia in 1871, into Japan in 1875 and into the Dominion of Canada in 1867. Their history in all these countries has been entirely satisfactory and most, if not all, the defects of private savings banks have been obviated. No record of a run has appeared in any case and the exceedingly slight losses have been borne by the government. Our own government being a large borrower and more appreciative of personal loyalty than any other has inducements to establish this system greater than any other government. A full description of a law proposed to be enacted by the United States Congress concluded the paper.

THE PROBABILITIES OF LOCUST OR "GRASSHOPPER" INJURY IN THE NEAR FUTURE, AND A NEW METHOD OF COUNTERACTING THEIR INJURY. By Prof. C. V. RILEY, U. S. Entomologist, Washington, D. C.

[ABSTRACT.]

PLAUSIBLE theories have been elaborated to show that there is a certain periodicity in locust visitations and a connection with such visitations and sun-spots. However this may be no one cognizant of the facts can doubt the connection between serious locust injury and business depression, or that there has been a certain periodicity in widespread locust injury, averaging about every eleven years. This last fact may explain the exceptional sensitiveness and anxiety which locust increase has this year caused among the farmers of the trans-Mississippi, as more than the average interval has passed since the last serious devastations began and just a decade since their height was reached.

The paper then explains how each year since 1877, except last year when he was absent in Europe, Prof. Riley has been able to analyze the data and give confident assurance of comparative immunity. He then considers the condition of affairs the present year. Much injury has been done in northern portions of California by *Melanoplus devastator*, but the laws governing this species scarcely affect the farmers east of the Rocky Mountain range. The fears expressed early in the season on account of the great abundance of young locusts in the Platte Valley country were shown to be groundless because only non-migratory species were concerned.

But the recent anxiety felt by the people of the Northwest has more real foundation, as investigation shows that not only are native or, for the most part, non-migratory species very abundant; but the true migratory species, viz., the Rocky Mountain locust, has greatly increased and is now moving in flights to the south and southeast. It is too early to say how extensively the eggs will be laid, but large areas in Montana and Dakota will undoubtedly be stocked.

There is also a great scarcity of the natural enemies of the species, and should the weather prove favorable for the next two years there will be a period of increasing injury. As encouraging offsets to this picture the author mentions the heavy storms and rains that have lately prevailed in that section of the country and emphasizes the fact that, under the most favorable conditions to

locust increase, the injury for various reasons, and chiefly the advance of settlement and cultivation, can never be as widespread as it had been between 1874 and 1877.

The paper concluded with the statement of a new remedy, that has been used with considerable satisfaction in California the present summer. While in the warfare there the methods adopted have been essentially the same as those advocated in the First and Second Reports of the U. S. Entomological Commission, the novel method mentioned consists of the use of arsenic, sugar, bran and water, the proportions being one part by weight of arsenic, one of sugar and five of bran, to which is added a certain quantity of water.

The arsenic and bran are first mixed together, then the sugar is dissolved in water and added to the bran and arsenic, after which a sufficient quantity of water is added to thoroughly wet the mixture.

About a teaspoonful of this mixture is thrown upon the ground at the base of each tree or vine and left to do its work. The poison works slowly, seldom killing its victim within less than eight or ten hours after having been eaten.

Professor Riley expresses the belief that this method of destroying locusts will prove very serviceable in gardens and orchards where the insects are not in excessive abundance, but he does not think it will compare with the ditching and burning, and other means mentioned in the Commission's Reports, in broad grain fields wherever the insects are as numerous as they have been in the Mississippi valley.

THE SILVER QUESTION. By E. B. ELLIOTT, Government Actuary, Treasury Department, Washington, D. C.

[ABSTRACT.]

Prior to the year 1873, the legal tender coinage both of gold and of silver was free or nearly so to all holders of bullion presenting the same for coinage.

From 1873 to 1878 the coinage of legal tender silver was discontinued but the then existing silver coinage was not demonetized.

Since 1878 a restricted but enforced coinage of legal tender silver obtains. The coinage of gold is free,—unrestricted. All depositors of gold bullion may receive gold coin at par in exchange for such bullion deposited.

The coinage of silver is not, like gold, free to depositors or holders of silver bullion.

The secretary of the treasury is required by law to purchase in open market the silver that is to be used for coinage.

The law demands of the government the purchase in open market, practically at its gold valuation, of from two million to four million dollars' worth of silver bullion each month, which bullion is to be coined into legal tender silver dollars; or from twenty-four million to forty-eight million dollars' worth of silver bullion each year.

This law has been in operation during the seven fiscal years since June 30, 1878, to the present time. The number of legal tender silver dollars coined, up to and including July 31, 1885, is officially reported as 205,784,381.

This excessive forced purchase and coinage of silver by the government, if continued, may result, in the early future, in the enforced use of silver and silver equivalents in the transaction of public and private business, to the exclusion of gold and gold equivalents.

Constant and earnest appeals and demands are now being made, from very many quarters, for the suspension of the coinage of this silver dollar, until the legitimate demands of commerce shall clearly require its resumption.

It is now well established "that along with one metal used as standard money, it is possible to keep in circulation a certain *limited* quantity of an over-valued inferior metal also passing as standard."

Since 1873, in our own country, the so-called double standard has ceased to be legally recognized as the unit of account; and it is believed that a double standard that is, a standard resulting from an effort to fix that which by the laws of trade is un-fixable, can never again be adopted by the commercial nations of the world.

Desirable to be done.

1. Suspend the purchase of silver bullion, and its coinage into legal tender silver dollars.

2. Increase the weight of the future subsidiary silver coin from twelve and a half grams for the half dollar, to fifteen grams; and in proportion for the quarter dollar, the dime, and it may be the half dime; and let the weight in grams and the decimal fineness be stamped on these coins.

3. Let silver in *bars* continue to be of nine-tenths fineness, and the weight of such bars be exact multiples of the gram,— the metric and destined international unit of weight.

4. Let periodical, say monthly, official announcement be made of the gold value of a decagram of silver of nine-tenths fineness, as indicated by the average market price in London and in New York, for the month immediately preceding.

INSURANCE AGAINST LOSS BY FIRE. By EDWARD ATKINSON, Boston, Mass.

COMPETITION AND COÖPERATION SYNONYMOUS TERMS. By EDWARD ATKINSON, Boston, Mass.

SOCIAL ECONOMY. By DR. JNO. MÜLLER, Ann Arbor, Mich.

VITAL STATISTICS OF THE COLORED PEOPLE OF THE SOUTHERN STATES. By DR. GEORGE W. HUBBARD, Nashville, Tenn.

ELECTRIC LIGHTING. By E. B. ELLIOTT, Government Actuary, Treasury Department, Washington, D. C.

ABSTRACT OF PROCEEDINGS OF THE SOCIETY FOR THE PROMOTION OF AGRICULTURAL SCIENCE, AT ITS MEETING HELD IN ANN ARBOR IN CONNECTION WITH THE MEETING OF THE A. A. A. S.

[Reported by the Secretary of the Society.]

THE Society for the Promotion of Agricultural Science was organized and the first meeting held in Boston, August, 1880.

Regular annual meetings have been held since, in Cincinnati, Montreal, Minneapolis, Philadelphia, and Ann Arbor. As its name implies, the Society was organized for the purpose of bringing together those who are interested in the application of science to agriculture, discussing the methods and results of investigations, and providing for publications relating to the same.

While the Society desires to extend its work and influence as rapidly as may be expedient, the original plan of its founders has been followed by inviting and admitting to membership only those engaged in work of scientific value.

The officers at present consist simply of a president, secretary, and one other elected member, who together constitute the executive committee. This committee has full charge of the business of the Society.

No constitution and by-laws have yet been adopted, this business being postponed until the experience of several meetings and full consultation among the members shall determine more definitely the scope of the Society and the best means of attaining the desired results.

At different meetings, the following action has been taken by the Society in regard to its affairs:

Voted,—(1880) That no paper shall be read before the Society unless previously presented to the executive committee in full or by abstract, and accepted by them.

Voted,—(1883) That in case a member of the Society shall neither be present at any meeting for three consecutive years, nor present a paper during this time, his name shall be dropped from the list of membership.

Voted,— That in the annual circular, members be reminded that the *ideal* of the Society can only be reached by making all papers presented adhere closely to original work and truly scientific methods and results,—without unnecessary argument or illustration, but bearing in mind that the end sought is to point out the practical aim and application connected with the subject treated.

At the meetings already held papers have been presented, generally relating to the special work of the respective authors. These have been read by or for the writers, the papers being then criticised and the subjects discussed by persons present, whether members or not. No record of the

discussions has yet been made. Papers by non-members are admitted, if examined and approved in advance by the executive committee.

The Proceedings of the Society will be published from time to time as matter of interest is collected. The first volume of the Proceedings, containing a history of the organization and papers presented at the first three meetings, was published in 1883. In the second volume will be found the papers prepared for the Minneapolis and Philadelphia meetings, and in the third the proceedings of the Ann Arbor meeting. The membership is limited to forty. At present there are thirty-six members representing about twenty states, including Canada. Nearly all are professors in agricultural colleges, or connected with experiment stations.

The following are the officers of the Society for 1886: President, Major Henry E. Alvord, manager Houghton Farm, Mountainville, Orange Co., N. Y.; Secretary and Treasurer, Dr. Byron D. Halsted, Professor of Botany, Iowa Agricultural College, Ames, Ia. Third member of Executive Committee, Edward M. Shelton, Professor of Agriculture, Kansas Agricultural College, Manhattan, Kansas.

At the last meeting Mr. J. J. Thomas presented a paper on "The Influence of Locality on Variations of Fruit," in which it was shown that actual experiments proved that locality had much to do in determining the character of a fruit. The most popular winter apples at the north become summer and autumn fruits in the south. The best sorts of the east are not of equal quality grown in the west and *vice versa*. Locality of origin has very little to do with the fitness of a fruit in any place. The pear is less influenced than the apple by external influences. A larger per cent of our foreign than of the native varieties of pears are of the first quality. The cultivator may enjoy the widest sources for selecting and testing fruit. Dr. E. L. Sturtevant presented two papers, one upon the "Dandelion," the other on the "Lettuce." Both of these plants have been known from early time and under many forms. These forms it seems are natural variations which have been secured and perpetuated by culture. This view helps to explain the permanence of the types. The three types of lettuce for example have been preserved but not produced by cultivation.

Prof. E. W. Hilgard presented an elaborate paper on "Some Redeeming Traits of the 'Alkali soils.'" The "Alkali" soils abound in potash, phosphoric acid and nitrogen and are therefore full of fertility, and as a secondary consequence moist. A dressing of plaster renders such a soil susceptible of profitable culture.

Prof. W. W. Tracy gave many striking examples of "Variations in Cultivated Plants." Cucumbers sometimes have the shape and warty surface of the crookneck squash. Occasionally they are like musk melons. White squashes planted on dark soil will successively grow darker in color. A stock of white summer crooknecks was obtained by soil-variation. Similar varieties are produced at about the same time in widely separated areas. A hard-shelled watermelon originated in Georgia, Illinois and Florida simultaneously.

Major H. E. Alvord presented some advances made in "Telemetric aids to Meteorological Records." By means of telemetry the readings of a

thermometer buried deeply in the earth may be recorded in any convenient place. The apparatus was described and its accuracy compared with other methods of obtaining soil temperatures.

Prof. C. V. Riley spoke of "a New Remedy for the Grasshopper" which has been employed in California. It consists of arsenic, sugar, bran and water mixed in given proportions. The mixture is thrown upon the ground and left to do its deadly work. Owing to the advance made in the settlement of the country and the increased area of cultivated land, the injury from locusts in the future cannot equal that of former years.

Dr. W. G. Farlow had a paper on "Some Injurious Fungi of California." He found fungi of the very destructive group Peronosporæ upon plants closely related to the tobacco, and there may be well grounded fears that they will spread to the latter plant and do much damage. Another fungus is abundant upon the hollyhock and it is probable that it may spread to the cotton plant, botanically a near relative of the hollyhock.

Dr. G C. Caldwell, presented "The Lactobutyrometer" with its latest developments. This instrument determines the quality of milk with sufficient accuracy for most purposes. The paper discusses the sources of error and variation. The process depends upon the solution of the butter fat in ether, and this involves the mooted question of the nature of the covering of the fat globule. The view now generally held is that the globule has a film of albuminous or nitrogenous matter that is not solid. If this film is thick the lactobutyrometer does not give as accurate results as when it is thin.

Prof. W. J. Beal gave further results of his experiments on "The Vitality of Seeds buried in the Soil." The seeds of twenty-three kinds of plants, were mixed with sand, placed in bottles and buried. The seeds were left for five years and then all tested. The seeds that did not germinate were dried and kept through the winter in the ordinary way. The next season many of these seeds germinated. Thus of the fox-tail grass nearly twice as many seeds germinated after the winter of exposure than before. Of the may-weed about the same number in both cases.

Prof. T. J. Burrill gave the results of "An experiment in Silk Culture." The worms became diseased and the bulk of the paper consisted in the consideration of the nature of this disorder and the conditions which led to the outbreak. This is a contribution to the bacteriology of this country, not easily abstracted.

Dr. H. P. Armsby presented a paper on "The Creaming of milk by the Cooley system," consisting very largely of tabulated statements of long series of experiments. It is established that the greater the difference of temperature between the milk and the surrounding medium, the more rapid the creaming. Milk set in water containing broken ice will cream thoroughly in twelve hours.

Prof. C. E. Bessey presented "The claims that Agriculture has upon Botanists," in which it was shown that the study of cultivated plants had been sadly neglected, particularly their physiology and pathology.

Discussion followed nearly all papers.

The annual meeting of the Society is held at the same place as that of the A. A. A. S., and opens on the day previous to the convening of the Association.

ABSTRACT OF PROCEEDINGS OF THE BOTANICAL CLUB OF THE A. A. A. S.

[Reported by the Secretary.]

THE attendance at Ann Arbor was much larger than its most sanguine friends had anticipated, there being eighty-five names entered upon the register. This gave the club twenty-three and one-third per cent of the total attendance of the Association, more than twice as great a proportion as heretofore. Thirty-seven of the members recorded the department of botany in which they are most interested. These were entered under twenty different headings, but may be reduced to four, as follows: flowering plants and ferns, nineteen; cryptogams, fourteen; physiology, four; and paleophytology, two.

Six sessions were held in all—four in the morning and two in the afternoon—each an hour long, all in the room of the biological section, with the exception of the one on Friday evening, which, by invitation, was changed to Professor Spalding's botanical laboratory. The numbers present at the sessions exceeded seventy-five for several and dropped the lowest at the laboratory gathering, when there were only twenty-eight.

The papers, notes and discussions were of just the kind for which the club was specially founded. Those who heard them cannot but have received much valuable information applicable to personal work, as well as having the pleasure of listening to the results of recent studies. The resumé which follows is necessarily very brief, and often omits the items which the listener may have found the most directly serviceable for his own needs.

THURSDAY, August 27, 9 A. M. The chairman made several suggestions of topics for the consideration of the club, which he had already formulated in the last number of the *American Naturalist:* 1. The necessity of uniformity in the use of English names of plant diseases and of the fungi producing them. 2. The advantage of uniform pronunciation of the Latin names of plants. 3. The distribution of botanical literature among the several journals so that each shall represent only certain departments of the science. 4. The relations of the botanists of the country to the National Herbarium at Washington.

In the discussion which followed it was clearly brought out that at present great confusion exists in the use of English names of plant diseases, *e. g.*, the term *blight* is given to the most diverse forms of fungi, as well as to many kinds of diseases either partially or wholly killing the plant. To some extent this confusion occurs in most of the English names now in use. It was also shown that the supply of English names was not adequate to the present needs of the subject. Mr. Arthur suggested that it might be possible to prepare a list of English names of fungous parasites and the diseases which they cause, which should be taken as the standard for this country, something in the same way as the

American Pomological Society exercises authority over the naming of fruits. After considerable discussion favorable to the suggestion, a committee was appointed to take the matter in charge and report at the meeting next year. The committee are J. C. Arthur, of Geneva, N. Y.; W. G. Farlow, of Cambridge, Mass.; W. Trelease, of St. Louis, Mo.; who are to act in conjunction with F. L. Scribner, of Washington, D. C., who is investigating plant diseases for the government.

The second topic was only partially discussed, but the prevalent opinion seemed to be that, although there was much annoyance from the variety of pronunciations, nothing could at present be done to secure uniformity.

The third topic was urged by the chairman, who represents the botanical department of the *American Naturalist*. The representatives of the *Botanical Gazette* preferred to select their material from the whole range of botanical literature. No representatives of the other journals wholly or partially devoted to botany were present, and no result was reached.

The fourth topic was taken up by Mr. Scribner, who spoke of several ways in which the National herbarium might be of direct service to the botanists of the country, and on the other hand of the duty which the botanists owe to the herbarium in the way of contributions of new material. It was brought out in the discussion that few present had any knowledge of the herbarium, or of the facilities for consultation. It was therefore urged that the first requirement was a full statement of the contents and condition of the National herbarium, in order that botanists may know what facilities it offers for present study, and what is desired to make it more complete. The club then appointed J. M. Coulter, and W. J. Beal a committee to take the matter under advisement and report at a later session.

THURSDAY, August 27, 5 P. M. Professor Beal gave some notes on teaching botany. He had found the movement of protoplasm to show well in the hairs on the young buds of many species of plants. The stem of *Smilax rotundifolia* served excellently for histological study. He was of opinion that usually too much time is occupied by lectures, and not enough by laboratory work. He had had students work in various ways, but obtained the best results when considerable time was given to each plant and fewer plants used. Professor Burrill finds difficulty in getting sufficient time for laboratory work. Professor Coulter would have the laboratory open from morning till 4 P. M., and permit students to come and go as convenient to them. Professor Bessey called attention to the scientific course in the University of Nebraska, which is arranged on a plan of alternation. Botany comes but twice a week, which gives plenty of opportunity for laboratory work. The same is true of zoology, physics, chemistry, etc. This arrangement works well when the several professors act harmoniously.

The subject of reagent bottles was then taken up and various devices illustrated and described, followed by a discussion of the several phases and methods of section cutting.

FRIDAY, August 28, 9 A. M. The committee on the relations of the botanists to the national herbarium reported as follows, and its report was adopted by the club:

It is the desire of the Botanical Club of the American Association for the Advancement of Science to assist in making the National Herbarium worthy of its name, that it may offer every facility for consultation and study. They would therefore recommend that as a step in this direction the Department of Agriculture make known to botanists,—

1. The contents of the herbarium.
2. The number of its types.
3. The completeness of its preservation.
4. Its convenience for consultation.

Committee { J. M. COULTER. W. J. BEAL.

Dr. Halsted exhibited specimens of Peronospora and Æcidium from Spirit Lake, Iowa. The former, *P. viticola*, was on wild grapes and so luxuriant as to cover the whole plant with a white velvet and prevented its reaching more than a foot or so in height. The latter was on Euphorbia, giving the host a peculiar upright growth.

Professor Coulter gave some notes on plants collected by the Greeley expedition to the Arctic regions.

Professor Barnes called attention to the peculiar mode of dehiscence of *Campanula Americana*, by means of a pair of circular trap doors on the sides of the capsule.

Professor Lazenby gave some additions to the published lists of the flowering plants of Ohio.

FRIDAY, August 28, 7 P.M. This meeting was held in the botanical laboratory of the University of Michigan. Professor Spalding first pointed out the facilities of his laboratory. A general discussion ensued on instruments, books of reference, laboratory methods, drawing, courses of study, etc., participated in by Professors Spalding, Bessey, Burrill, Halsted, Campbell, Barnes, Beal and Coulter. This was a specially delightful and profitable meeting to those who were present.

MONDAY, August 31, 9 A. M. The election of officers for the coming year resulted in the selection of J. M. Coulter as chairman and J. C. Arthur as secretary.

The subject of the work at Washington on the diseases of plants was then introduced. The following address was presented and, after some discussion upon the best wording of the last clause, was adopted as the unanimous expression of the club:

To the Honorable Commissioner of Agriculture:

The members of the Botanical Club of the A. A. A. S., recognizing the importance of the movement so happily inaugurated by you, whereby provision has been made for the investigation of plant diseases, would hereby assure you of their hearty support in all your efforts to procure the necessary means for carrying out the work proposed. Inasmuch as researches of this nature will require a considerable expenditure of money, the members of the club hereby pledge themselves to use their influence in inducing their representatives in Congress to make a liberal appropriation therefor in accordance with your estimates.

Mrs. Walcott, of Boston, suggested that a copy of the address be furnished each member of the club, to be presented to his representative in Congress. a suggestion which met with approval.

Professor Burrill spoke of a form of grape rot which had only been recently recognized in this country as a distinct disease, although well known in Europe. It has usually been referred to *Phoma*, but does not have its spores in minute cavities or perithecia as in that genus. It is *Sphaceloma ampelina* DeBy. The spores are unable to germinate on a dry surface, so that sheltering the grape clusters prevents its attack. He also exhibited grape leaves bearing *Phoma uvicola*, a mode of occurrence which had been denied.

Mrs. Walcott gave an account of a Campanula, probably *C. Americana*, which made its appearance in some unaccountable way in a row of wild flowers raised from seeds from other localities. These seeds were sown in 1880, and the plants moved to another spot last season. This year there appeared two stalks of the species referred to, apparently, but having some of the flower buds two inches long, the calyx bristly and the flower in eights throughout. She had also observed seedings of *Yucca filamentosa* near a plant of that species in the garden.

Considerable discussion followed. Mr. Campbell had known of *Yucca* fruiting in Michigan. E. F. Smith recited a case in which weed seeds had appeared to lie dormant for fifteen years or more. It was suggested that in this case there might have been a succession of very depauperate individuals, as some large weeds can fruit and so perpetuate themselves without reaching more than an inch or so in height, and thus escape observation.

Professor Barnes called attention to the erroneous figures of the stomata of Marchantia in all English works on botany. They are shown with six cells in circumference, whereas they have only four. The shapes of the innermost cells, the true guard-cells, and of the outermost cells of the chimney-like stoma are not, as a rule, correctly drawn.

F. L. Scribner exhibited some fine drawings of grasses from which photo-engravings had already been taken, and explained how they were made.

TUESDAY, September 1, 9 A. M. A paper from George U. Hays of St. Johns, N. B., on botanical features of New Brunswick was read.

D. H. Campbell gave some hints on growing the spores of *Botrychium ternatum*. The spores are devoid of chlorophyll both before and after germination, which suggests that they should be grown in rich earth or humus. When prothallia of similar plants have been found they have been below the surface of the ground, and he had devised a plan for sowing the spores under the soil yet so as to be kept under constant observation. The spores of most ferns were germinated in water at ordinary room temperature, and when desiring to carry the growth very far were transferred to some solid substance and kept moist under a bell-jar.

The same speaker had found tabular crystals in the base of the petiole of *Onoclea struthiopteris*, which the usual micro-chemical tests proved to be oxalate of lime.

Professor Bessey explained a convenient form of herbarium doors.

J. C. Arthur exhibited specimens of barley, the so-called *Hordeum trifurcatum*, in which the awn of the flowering glume is jointed and bears more or less perfect flowers.

Dr. Walker of New Orleans spoke of the dwarfing of corn grown in a flower pot in his window. Others mentioned similar phenomena.

Mr. Arthur called attention to the erroneous use of the word fungoid by nearly all English-speaking botanists. It is properly applied to growths whose origin is not known or which bears some resemblance to a fungus. It cannot, however, be properly applied to a fungus or its product. The word almost always intended is either the noun *fungus* or the adjective *fungous*. As a spheroid cannot be a sphere so a fungoid growth cannot be a fungus or a fungous growth.

EXECUTIVE PROCEEDINGS.

REPORT OF THE GENERAL SECRETARY.

GENERAL SESSIONS OF THE THIRTY-FOURTH MEETING OF THE ASSOCIATION HELD IN UNIVERSITY HALL, ANN ARBOR, AUGUST 26 TO SEPTEMBER 1, 1885.

WEDNESDAY MORNING, AUGUST 26.

President LESLEY in the chair.

The proceedings were opened by an eloquent invocation by the Reverend S. HASKELL of Ann Arbor.

Professor LESLEY with a few appropriate words introduced Professor NEWTON, the President elect, who then assumed the chair resigned by Professor LESLEY, and addressed the Association as follows:—

LADIES AND GENTLEMEN, MEMBERS OF THE AMERICAN ASSOCIATION:—You have called me to a post of honor and duty. I prize greatly the honor of having my name added to the list of eminent men who have presided over your sessions in years past, and I thank you for that honor. The duty I will try to do in a spirit of courtesy and fairness to the best of my powers. I am conscious, however, that if this, our gathering at Ann Arbor, shall be a successful and pleasant one, the credit will be due far more to the permanent officers, to the sectional officers, and to the local committee than to anything I can say or do.

The President introduced the Hon. RUSSELL A. ALGER, Governor of Michigan, who was greeted with warm applause. After it had subsided, the Governor, on behalf of the State, welcomed the scientists to the State of the Great Lakes. He said: He supposed everybody was acquainted with Michigan, which, for its production of lumber, minerals, agricultural produce and pretty women, is justly famous. And Michigan, which ranks sixth from the top of the ladder with her sisters in point of productiveness, ranks second to none in generous hospitality which she tenders to your honorable body.

The President then introduced the Hon. THOMAS M. COOLEY, who on behalf of the Local Committee welcomed the Association in the following words:

Fifty-five years ago, when Detroit was still a small frontier town, the major part of its inhabitants of French descent, and many of them speak-

ing only the French language, a young man, who had just attained his majority, came to the town on the invitation of leading citizens, to deliver public lectures on chemistry, geology and other natural sciences. He had been found at Troy, N. Y., by a committee who had gone in search of such a lecturer, and had been recommended as a suitable and competent person by the well known Prof. Amos Eaton. We are not surprised to learn that the committee engaged his services with some hesitation, and that when he came on he was received as a teacher with incredulity; for he could hardly be thought learned beyond what was to be found in books, and even as to that he could not be expected to have that maturity of judgment which would seem necessary to fit him to handle his materials with usefulness to hearers. But the young man fully justified the recommendation which had been given of him. He was an enthusiast in science. He had already had considerable experience as a practical chemist and had studied geology and botany in the woods and hills at the foot of the Alleghanies in western New York, and his energy and geniality were such as made his enthusiasm contagious. He had among his constant and most interested hearers George Cass, the territorial judges and other dignitaries, and was soon the leader in all scientific movements and investigations which were entered upon in the new territory, and he was so ready and thorough in his work that others naturally deferred to him, so that he soon came to be considered an authority. In 1831, he was selected to accompany Henry R. Schoolcraft in an exploring expedition to the head-waters of the Mississippi, the result of which as his share of the labor was an able and valuable report upon the botany of a region which before was almost unknown to the country.

Long before this time there had been rumors of great mineral wealth on the shores of Lake Superior, and it was known that the Indians had decked themselves with copper ornaments procured there from the earliest days. It was also known there were numerous salt springs in the state and expectations ran high that these would prove a great source of public wealth. Attention was directed to the young geologist as the suitable person to investigate and make known the extent of these sources of wealth, and in 1837 when the territory took on the form of state government, one of the very first things provided for was the office of state geologist to which this young man, DOUGLASS HOUGHTON, even then but twenty-eight years of age, was appointed.

His appointment proved every way admirable. A plan for a thorough geological survey of the state was soon matured, which was so comprehensive in scope as to leave little for subsequent improvement. Four departments were contemplated: one of geology and mineralogy proper, one of botany, one of zoology and one of topography. In each of these there was to be an official head and assistants, but all were to work in cooperation and all under the general supervision and direction of the state geologist himself. To make the work more complete and thorough, skeleton maps were provided according to the federal land survey, and upon these were to be brought the results of the explorations, so that the

skeleton maps would be converted into admirable maps of the townships, showing their topography and natural features as they were found by the several explorers.

This is not the proper occasion for entering upon a detailed examination of the work done—work very familiar to the people of Michigan, but naturally of less interest to others. It will be sufficient now to say that several years of most valuable work was done under this plan, one of the most significant results of which was that the people of the state, through the reports of the state geologist, were made fully acquainted with the wonderful extent of mineral wealth beneath its surface, and the world was at length brought to know that the agricultural possibilities of Michigan, which had been thought to be limited, were in fact of the very highest promise.

Unfortunately, the State was nearly bankrupted by the over-ambitious enterprises of its youth, and it became necessary to suspend the State Survey. The geologist, however, did not for a moment pause in his scientific studies and investigations. It has been justly said of him that "hardship and labor had no terrors for him in the prosecution of his favorite studies. He was no mere theoretical geologist. He loved better to study the operations of nature in his own workshop than to read the theories of any man in his parlor. His mind could be satisfied only when he had put everything into the crucible and tested it for himself."

Such a mind could not rest and rust. He was one of the founders of the Association of American Geologists and Naturalists—the Association which was the precursor of the one which meets here to-day—and it is this fact, and the fact that he was the first occupant of the Chair of Geology in the University in whose halls we meet, that justify his being brought to your remembrance now. As a member of the Association, he devised a scheme of enlarging the scope of the national surveys so as to make them embrace a thorough geological, mineralogical, topographical, and magnetical survey; and he so impressed the wisdom of his plan upon the minds of his associates, that they sent him as a committee to Washington to secure the proper action to give his plan effect. His reception was cordial, but difficulties were raised: the additional expense was one; the difficulty of procuring competent men for the work was perhaps more serious. Dr. Houghton put aside the objections as of little moment, the expense ought to be increased but slightly, and he was so confident of the feasibility of his plan, that he immediately proposed to take and was given a large contract for surveys according to it. It was while engaged in carrying out this contract, that one of the most enthusiastic and promising scientists of America met his death by drowning off the shores of Lake Superior while as yet but 36 years of age.

I deem it proper to touch thus briefly upon the career of this gifted young man, not only for what he did in science and because he may be deemed one of the originators of this association, but also because he was a thoroughly practical man, and had the true conception of the place of

science in the state, as the enlightener of legislation and the necessary guide in a large part of all that pertains to internal regulation. It is not an uncommon supposition that the man devoted to science stands apart from his fellows, delving into matters that are curious rather than useful, and that practical men may pass him by as a dreamer who is not to be taken into account in the great movements of the day. Even now, after science in half a century has almost made a new world of the habitable globe, there is still very much of this feeling, and perhaps the geologist most of all is looked upon as a visionary, who goes about with his hammer beating the dumb stones to make them tell him the unfathomable mysteries of creation, and pretending to read in the undecipherable hieroglyphics of nature the evidences in support of his fanciful theories. But the thoroughly practical turn of Dr. Houghton's mind was known to all his fellow-citizens and had been demonstrated even before he made his advent into Michigan. He it was who so far as I know first utilized natural gas; beginning a use for illuminating purposes in southwestern New York which is continued to this day. He had also begun even thus early the manufacture of percussion powder, but was stopped by an accidental destruction of his works. But his chief work was in Michigan, where he had located the first salt wells: planting them not where the general public had expected from the surface indications, that he would, but where his study of the rocks had satisfied his judgment the great deposits were secreted. He made no mistake, and the rocks poured forth their hidden wealth at his touch. When the storm occurred which brought his busy and useful career to a close, many people in the state had been looking forward to making him its chief magistrate, in the belief that at a time when the state was in urgent need of practical men at the head of affairs, no more suitable person was to be found. It is forty years since he passed away: had the storm spared him he might perhaps have been with us to-day; for his genial and elastic spirits contained ample promise of old age; and the old age of such a man, like his youth, would have been one of unwearying labor and grand achievement.

Such a career is well calculated to impress us with the intimacy of the relations between science and the state. Possibly their relation may justify me in standing before you to-day, though I make no pretensions to scientific knowledge, and cannot claim the honor of a membership in your association. You represent to-day a family of natural sciences; related, because all truth is related; so that you may pursue your investigations in harmony and cooperation, following whithersoever the truth shall lead. But although much of the inducement to this will be the mere pleasure of the investigation itself, there will also be a practical side which will not be overlooked. On that practical side at all times will be another science, which I may assume to represent to-day: the science of law; which, if not a member of your family, is at least so near a neighbor as to be entitled to the customary privileges of borrowing and lending. In many ways the state represented in its law must be debtor

to science, though I am sorry to be obliged to confess that she is quite too apt to give short measure in repaying the obligation.

To-day a great country in Europe, once its leading country, as it might perhaps have been yet but for the unyielding intolerance and persistent repression of its civil and ecclesiastical rules, is suffering under a fearful visitation of Asiatic cholera. Consternation is everywhere, and the living scarcely summon courage to bury their dead out of their sight. But the most mournful fact attending the scourge is that ignorance to a large extent supplies the victims, and hands them over bound and helpless, as the priests of old supplied them to Moloch, and men die by the hundred because they do not understand and have never been taught a few plain truths of natural science. The physician, who in their distress endeavors to show them that the plague is nature's punishment for foul living and the habitual inhaling of poisonous air, is in danger of being torn in pieces as a man who is probably spreading the disease under a false pretence of trying to check it.

In a neighboring province a large city is suffering an equally severe scourge of small pox. As in Spain, the poor and the ignorant are the chief sufferers. Science long since demonstrated the existence of an almost perfect preventive, but prejudice runs strong against it, and parents resist its application and allow their children to die rather than submit to it. It is a mournful and most discouraging fact, for the city in which the pestilence is thus holding high carnival is one in which the general standard of intelligence is high.

In cases like these the law has an important field of action, which we may admit has never been satisfactorily occupied. It is the business of the state to protect the people even against themselves within certain tolerably defined limits. No man has a right, through ignorance or otherwise, to take the life of wife or children, or even of himself; and the law, when the need is apparent, should interfere to prevent it. Especially, should it interfere to prevent the spread of great pestilences. If science and law could hand in hand visit the sources of cholera in Asia, in the plenitude of enlightenment on the one side, and of irresistible power on the other, who will doubt their ability to strangle in its birth this thing of terror and destruction? But it starts off now with the strength of a giant, and wherever it goes its ravages are proportioned to the want of enlightenment.

It is sometimes thought that the law is a laggard in these matters, and that legislators are culpable that they do not devise and put in force more effective measures for compelling the observance of sanitary laws. But is it certain that those who thus complain do not mistake the place of law in the social state? Law cannot be a pioneer: and in all that relates to sanitary laws, science must be the John the Baptist to prepare the way for it. To give sanitary regulations to the Arab pilgrim to Mecca, who drinks in pestilence with the foul water of its holy well, would be like in wisdom to the formal delivery of the ballot box as a means of civilization

to the Comanche Indian. The people may be expected to make good use of such law as is approved by their understanding and sanctioned by their judgment; but they will neglect and contemn, if they do not openly disobey and resist any other. The law, therefore, must follow modestly in the wake of science, planting itself firmly wherever the ground has been thoroughly prepared for it through the diffusion of general intelligence, but not attempting the vain task of leading where it is certain the people, whether from prejudice or want of information or other causes, will refuse to follow.

What has been said in regard to sanitary laws is only expressive of a general truth. It is the same in the field of political economy: it is the same wherever science and the state come into important relations. Poor Rebecca Nourse was executed, not for want of law to protect the innocent, but for the failure on the part of court and people to apprehend scientific truth; it was the terrible fact that law had accepted ignorant superstition for its guide, to which she owed her martyrdom. What the poor victim of delusion needed was less law and more science; and that also was what Galileo wanted, when with the hand of ignorant power upon his throat he could only whisper his protest, "but it does move notwithstanding."

The American people have recently been at great trouble and expense to elevate in their leading city a colossal statue, presented to them by an old ally, and supposed to represent Liberty enlightening the World. The exact idea that was in the mind of the man who planned the gift it might be difficult to ascertain; and probably the most of those who contributed to it did not pause to inquire. But, doubtless, we should all agree that there may be a liberty that does not enlighten, except as it conveys a warning; and that illustrations may be found in America as well as elsewhere. The true liberty that enlightens the world is the liberty of untrammelled investigation and discussion; that seeks fearlessly for the very truth of God in every direction, regardless of tradition or dogma, or prince or people, and that proclaims the truth when found until even an unwilling people, in spite of prejudices and prepossessions, is compelled to listen and understand it. But there can be no valuable liberty to the people who are at once ignorant and content in their ignorance. To the man who lives in want and misery because he is ignorant of such natural laws as if obeyed would lift him above want, it is the same as if such laws were not in existence; and political despotism could scarcely make his case more hopeless.

Assuming, therefore, for the time being to represent the legal profession, I take great pleasure in welcoming this association to our little city. No doubt its deliberations will be, as they always have been at other meetings, of great interest to members, and lend largely to the advancement of scientific knowledge. But those of us not immediately sharing in its work may take satisfaction in looking forward to ultimate results; making sure as we rightfully may, that whatever tends to develop and

verify the truths of science, and to spread a knowledge of them among the people, must in large degree be useful in preparing the way for better laws, and for a more rational and beneficent liberty.

The President next introduced President JAMES B. ANGELL, who, on behalf of the University of Michigan, said:—

MR. PRESIDENT AND MEMBERS OF THE ASSOCIATION:— It is my pleasant duty, speaking in behalf of the Regents and of the Senate of the University, to give you a most cordial welcome to these halls. It may well be believed that the University hails your coming with special delight, for her functions and yours are in large part the same. She like you all is called to interrogate nature, to study man, and if possible to discover scientific truth. Like many of you she must give a large part of her force to teaching scientific truth. She finds as you have found, that these two functions of investigation and of instruction are not incompatible. Much complaint is made, and sometimes justly made, that our scientific scholars are so burdened with the duties of teaching that they have neither time nor strength left for investigation. We are asked to establish foundations for the support of research alone. Commendable as are such foundations, it is cheering to the University and college men to see how much of the most fruitful research, whether on this side of the ocean or on the other, is accomplished by men who are doing both the work of instruction and that of investigation. Is it perhaps true that the scholar, who is held by his duties constantly and strenuously in close and vital relations with the fundamental truths of his science, is protected from the vagaries and visions which sometimes beset the enthusiastic investigator, who is not thus frequently recalled to his starting point? It is certainly true that the work of instructing ardent and sympathetic young minds tends to clarify and stimulate the mind of the teacher, and that in the attrition of the minds of pupils and of teachers sparks of truth are often struck out which would otherwise never have been seen. Standing under this roof, I may be pardoned if while commending all rational plans for enabling some scholars to give all their time to research, I express the strong desire that friends of good learning may so generously endow the departments of scientific instruction in her colleges and universities that in every one of them some one Professor of each science may, while he gives instruction, have a liberal share of his time and a liberal supply of means for investigation and research. What a corps this would furnish of trained men, brimful of the best enthusiasm, for pushing out the frontiers of scientific knowledge! I know of no agency so fitted to assist in accomplishing this high end as this Association. The University may therefore well rejoice in your work and in your presence.

I think I may say without impropriety that this University has always been as generous as its means would allow in fostering scientific work. The demands upon it have constantly outrun its means. Such is the case with most educational institutions. Judge Cooley has spoken in fitting terms of one of the distinguished professors whom it early called into its

service and whose death was so heavy a loss to the University, to the state and to science. It may interest you to know that the very first professor the University appointed to any chair was Dr. Asa Gray, the profound and modest scholar, whose name is so honored wherever scientific learning and nobility of character are respected. This institution was one of the very first to establish a scientific course leading to an appropriate degree. Several of our teachers have long been laborious and honored members of this Association. The modesty of the living forbids more specific reference to them. But I am sure that many of you, as you gather under the shadow of our Astronomical Observatory, will experience anew a pang of the sorrow which is here so keenly felt and which the whole scientific world sincerely felt at the early and what seemed to us the untimely death of WATSON, whose brilliant genius wrote his name and that of the University which reared him, and which he so long and faithfully served, high among the stars, to be read and known of all men.

Ladies and gentlemen, because, as we believe, this University has a love like yours for the sciences you cherish, we are grateful for your coming. We expect to receive instruction, stimulus and inspiration from your visit. We need your help, we are but young. The first class was received here in 1841, a period quite within the remembrance of a large part of this audience. Some of you had graduated from college before that date. Men are living, it is said, who have shot wild deer on the ground which now forms our campus. Under the generosity of the United States government and of the State of Michigan and through the wise administration, at least of those who have gone before us, who are now charged with the care of the institution, it has attained a fair degree of prosperity.

The work here is organized in six departments: the department of literature, science and the arts (or the collegiate) including the school of engineering and the school of political science, the department of medicine and surgery, the department of law, the school of pharmacy, the homœopathic medical college and the dental college. It has graduated nearly 8,000 persons. It graduates annually in these years from 350 to 400. The aggregate attendance of students has, in recent years, ranged from about 1,400 to nearly 1,550. Students of both sexes are admitted to all departments on terms of absolute equality. I am sorry that our students are not here to greet you with the enthusiasm of the young West. A college or university in vacation always reminds me of a mill with the machinery stopped and the pond run dry. It is not very interesting. But our halls, our laboratories, our collections, our libraries and a good number of our professors are here, and whatever we have, whatever we are, all are at your service. Welcome, thrice welcome to you all. May you receive from this meeting pleasure and profit which shall bear at least some small proportion to that which we know we are to receive, and for which we desire most heartily to thank you in advance.

His Honor, Dr. JOHN KAPP, Mayor of the city of Ann Arbor, was introduced and said:—

MR. PRESIDENT, LADIES AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:—

This municipality has honored itself in inviting you the most eminent representatives and votaries of science in this great nation, to assemble here for your deliberations.

In behalf of this City's representatives and citizens, I bid you one and all a hearty welcome. We are not unmindful that your presence here is, not because of any particular regard for this municipality, not because of any particular regard for the inhabitants of this beautiful city, but because your interest like ours clusters around and centers in this great University.

These walls, these buildings, and these beautiful grounds bear witness to the liberality of the General Government and of this state and this city.

But sixty-one years ago, on this delightful spot, then so beautiful as to be justly named Ann's Arbor, the first white man reared his log cabin and all around was the great "forest primeval."

Within that short space American industry, enterprise, energy and thrift have not only built up for themselves elegant homes, and great fortunes, but have reared a University renowned in all lands even to the Orient.

Towards its founder the first great chancellor, and those who have so ably carried on his great work, we entertain the highest respect and the greatest affection.

Justly indeed are our people proud of this greatest seat of learning and science west of the Alleghanies, and from its professors' chairs and classic halls, already have two been called to preside over and direct an Eastern University, second only in fame and renown to the University of Michigan.

During the time you may favor and honor us with your presence we cordially extend the free western hospitality in its homely phrase to "Make yourselves at home." Our citizens will be glad to know more of you, to greet you by the hand, and to make your stay among us pleasant, and we hope profitable to you. Our pleasant streets, our shady drives, our healthy location, our hills furnishing views of miles of as rich an agricultural country as ever the sun shone upon, will we trust be remembered as forming an oasis in the desert of life's drudgery. And permit me to remind you also that here, you are in one of the most prosperous, and successful fruit growing sections of the country, farms devoted to fruit culture in the hands of men who are no mere amateurs as scientists.

Although manufacturng industries are by no means limited, you will in our inhabitants—given largely to scholastic pursuits and scholastic attainments—doubtless miss much of the bustle, mad rush and strife of business; but you will find sober-minded, candid-thinking, cultured men,

and accomplished beautiful women. And for these, as their representative, I in their name give you a cordial greeting. The freedom of the city is yours, and when we speed you parting guests it may be with the well grounded assurance, that there remain with you, as with us, lasting memories of days pleasantly and profitably employed.

Professor NEWTON replied to the addresses of welcome in the following words:—

GENTLEMEN:—In the name of the American Association for the Advancement of Science, I thank you and those for whom you have spoken for your welcome and encouragement. This Association has for its object the advancement of science, a worthy, a noble, practical object. The subjects discussed do not include "everything that can interest a free and virtuous people," but they are limited by no narrow bounds. Nine sections covering nine large empires in the world of knowledge are parts of the permanent organization of the Association. We invite you to attend the meetings of the Association, and its sections.

The sections of Chemistry and of Mechanical Science very appropriately in these halls of instruction will, for a part of their time, give special attention to methods of teaching. The Geographers may invite you to go with them to the ends of the earth, the Geologists down into its strata, or back into geologic ages. Another section will discuss life, and the forms and behavior of living things. In the section of Anthropology, special interpretation is given to the old saying that the proper study of mankind is man. The Physicists will discuss the energy that in varied forms fill the world with action and life. The Microscopists will ask you to consider the exceedingly minute worlds near the homes of the atoms, and the Astronomers those distant specks of light in planetary and stellar space.

You must not be surprised if in the section of the exact sciences where all the ground is solid and the foundations sure you should be shown the flatland of two dimensions, or the four dimensional space with its wonderful complexities, or twisted worlds of three dimensions where the adventures of Alice in wonderland and behind the looking-glass are more than equalled in sober geometry. Or you may turn from these imaginary and less directly practical subjects to the section of Economic Science and Statistics where the real and immediately practical and ever-pressing question is to be discussed, "What shall the poor man eat."

To any of the varied discussions we cordially invite you.

The GENERAL SECRETARY announced that all Special Committees must report to the Standing Committee on Saturday morning; he called attention to the duties of the sectional committees; stated that all titles of papers must be accompanied by abstract or they will not be considered by the Standing Committee, and that the manuscript of all papers to appear in the proceedings must be in the Secretary's hands before the final adjournment, in accordance with the vote of the Standing Committee.

The PERMANENT SECRETARY announced amendment to Article 31 of the

constitution, the object being to change it so as to require all authors to hand in their manuscript for publication before the final adjournment of the Association.

The PERMANENT SECRETARY read the following list of the members and fellows, notices of whose death have been received since the Philadelphia meeting.

BENJ. ALVORD, Washington, D. C. Joined at the 17th meeting. Died Oct. 16, 1884, at the age of 71.

HENRY W. BLAIR, Washington, D. C. Joined at the 26th meeting. Died Dec. 15, 1884.

JOHN BULL, Washington, D. C. Joined at the 31st meeting. Born Aug. 1, 1819. Died June 9, 1884.

JOSEPH CHESTER BURKE, Middletown, Conn. Joined at the 29th meeting. Died 1885.

LOUIS M. CHEESMAN, Hartford, Conn. Joined at the 32nd meeting. Died in Jan., 1885, aged 72 years.

JOSEPH S. COPES, New Orleans, La. Joined at the 11th meeting. Born Dec. 9, 1811. Died Mar. 1, 1885.

JOHN D. CREHORE, Cleveland, Ohio. Joined at the 24th meeting.

LOUIS ELSBERG, New York, N. Y. Joined at the 23rd meeting. Died Feb. 19, 1885, aged 48 years.

HENRY L. EUSTIS, Cambridge, Mass. Joined at the 2nd meeting. Born Feb. 1, 1819. Died Jan. 11, 1885.

ROBERT JAMES FARQUHARSON, Des Moines, Iowa. Joined at the 24th meeting. Died Sept. 6, 1884.

Mrs. MARY E. MORGAN, Rochester, N. Y. Joined at the 31st meeting.

W. A. NORTON, New Haven, Conn. Joined at the 6th meeting.

JAMES ORTON, Poughkeepsie, N. Y. Joined at the 18th meeting. Died Sept. 24, 1877.

ISAAC J. OSBUN, Salem, Mass. Joined at the 29th meeting.

JOHN C. PHILLIPS, Boston, Mass. Joined at the 29th meeting. Died March 1, 1885, aged 46 years and 9 mos.

ROBERT E. ROGERS, Philadelphia, Pa. Joined at the 18th meeting. Died Sept. 7, 1884.

BENJAMIN SILLIMAN, New Haven, Conn. Joined at the first meeting. Born Dec. 3, 1816. Died Jan. 14, 1885.

CHARLES A. SMITH, St. Louis, Mo. Joined at the 28th meeting. Died in 1884.

J. J. WOODWARD, Washington, D. C. Joined at the 28th meeting. Born Oct. 30, 1833. Died Aug. 17, 1884.

WAYMAN CROW, St. Louis, Mo. Joined at the 28th meeting. Born March 7, 1808. Died May 10, 1885.

HENRY B. PARSONS, New York, N. Y. Joined at the 30th meeting. Born 1885. Died Aug. 21, 1885.

ALBERT TODD, St. Louis, Mo. Joined at the 27th meeting. Died April, 1885. Aged 72.

The PERMANENT SECRETARY announced that one hundred papers had been received so far for the present meeting.

Announcements were made by the LOCAL COMMITTEE, and were printed on the daily program.

The following invitation to the Association was read by Prof. WINCHELL:

Dr. ALEXANDER WINCHELL, ANN ARBOR, MICH.

Chairman of Excursion Committee for Meeting of the American Association for the Advancement of Science.

DEAR SIR:

The undersigned, a Committee representing the citizens of Detroit, respectfully invite the Members of the American Association for the Advancement of Science to an excursion to Detroit, and from there, by boat, to the Rock Salt Wells at Marine City, and to the Oakland Summer Resort on the St. Clair River, upon Saturday, Aug. 29, 1885.

A special train, upon the Michigan Central Railroad, will leave Ann Arbor, for your accommodation, at 7 o'clock A.M., standard time, on that day, and will return so as to reach Ann Arbor at 8.45 P.M., of the same day.

Trusting that we may be honored by the acceptance of this invitation, we are,

Very respectfully yours,

JAMES F. JOY,
BELA HUBBARD,
JAMES MC MILLAN,
STEPHEN B. GRUMMOND, Mayor,
Committee.

BRYANT WALKER,
Secretary.

Eighty-two new members were elected.

It was voted to adopt the recommendation of the STANDING COMMITTEE that morning sessions of the sections begin at 10 and close at 12½ o'clock, and afternoon sessions begin at 2 and close at 5 o'clock.

Amendment to Article 3 of the constitution was adopted so that it now reads:

Art. 3. Any person may become a member of the Association upon recommendation in writing by two members or fellows, and election by the Standing Committee.

Prof. WILLIAM HARKNESS of Washington, D. C., was elected Vice President of section A, in the absence of the Vice President elect.

Prof. S. P. LANGLEY of Allegheny, Penn., was elected Vice President of section B in place of Professor Brackett, resigned.

WEDNESDAY EVENING, AUGUST 26.

President NEWTON in the chair.

The GENERAL SECRETARY announced Capt. Corthell's lecture for Friday evening.

The PRESIDENT then introduced the retiring President who delivered his address which is printed in full in the present volume.

Prof. JAMES HALL in a brief, eloquent speech moved a vote of thanks to President LESLEY; the motion was seconded by Dr. T. STERRY HUNT and was carried unanimously with acclamation.

THURSDAY MORNING, AUGUST 27.

President NEWTON in the chair.

The following elections of officers to fill vacancies were made:—

Prof. N. T. LUPTON, Vice President of Section C.
Prof. T. J. BURRILL, Vice President of Section F.
Rev. J. OWEN DORSEY, Vice President of Section H.

The election of new members 83-110 by the STANDING COMMITTEE was announced.

The GENERAL SECRETARY announced that in compliance with the wishes of many members who desire to hear the papers in Sections A and B, it has been arranged that for the present each of these sections will hold but one session daily; Section A meeting immediately after the adjournment of the general session, and Section B at 2 P. M.

The GENERAL SECRETARY announced that members and fellows interested in Section G are requested to be present in that section this afternoon at 2.30 o'clock to discuss the proposed fusion of the section with Section F.

The CHAIRMAN OF THE COMMITTEE ON EXCURSIONS made some announcements concerning the excursions.

FRIDAY MORNING, AUGUST 28.

President NEWTON in the chair.

The GENERAL SECRETARY announced that the STANDING COMMITTEE made the following recommendations:—

1. That the Constitution be so amended that the name of Section D, be changed to Mechanical Science and Engineering.

2. That the Constitution be so amended as to fuse Section G with section F.

The SECRETARY further announced that both these amendments were proposed at the request of the sections principally concerned and read the following resolution passed by Section G:

Resolved: That Section G requests the Association to fuse Section G with section F.

The SECRETARY further announced that in accordance with the constitution the proposed amendments were announced last year in general sessions, but owing to an error of the secretary the announcements are not included in the official records; therefore the Standing Committee recom-

mend that the records be so amended as to make these announcements appear.

It was moved, seconded and carried that the records be thus amended.

It was moved, seconded, and after due explanation by Professor THURSTON of the object of the change, carried, to adopt the amendment to the constitution in regard to Section D, as recommended.

It was moved, seconded, and carried, to adopt the amendment of the constitution in regard to Section G, as recommended.

On behalf of the SECRETARY, Prof. S. P. LANGLEY read the following resolutions recommended to be passed by the STANDING COMMITTEE:—

Whereas, The attention of this Association has been called to the articles in the public press, purporting to give and presumably by authority, an official report of a commission appointed by the Treasury Department to investigate the condition of the U. S. Coast Survey Office, in which report the value of certain scientific work is designated as "meagre."

And whereas this Association desires to express a hope that the decision as to the utility of such scientific work may be referred to scientific men.

Resolved, That the American Association for the Advancement of Science is in earnest sympathy with the government in its every intent to secure the greatest possible efficiency of the public service.

Resolved, That the value of the scientific work performed in the various departments of the government can be best judged by scientific men.

Resolved, That this Association desires to express its earnest approval of the extent and high character of the work performed by the U. S. Coast Survey, especially as illustrated by the gravity determinations now in progress, and to express the hope that such valuable work may not be interrupted.

Resolved, That this Association express, also, the hope that the government will not allow any technical rule to be established that shall necessarily confine its scientific work to its own employés.

Resolved, That, in the opinion of the American Association for the Advancement of Science, the head of the Coast Survey should be appointed by the President, with the advice and consent of the Senate, should have the highest possible standing among scientific men and should command their entire confidence.

Resolved, That copies of these resolutions shall be prepared by the general secretary and certified by the President of the Association and by the Permanent Secretary, and shall be forwarded to the President of the United States, the Secretary of the Treasury and given to the press.

It was then moved to accept the report and adopt the resolutions. The motion was seconded by Prof. THURSTON who with Prof. JAMES HALL, Capt. COFFINBERRY, Prof. ALEX. WINCHELL, and Prof. MENDENHALL, spoke in favor of the resolution and were warmly applauded. The motion was carried by a unanimous vote.

FRIDAY EVENING, AUGUST 28.

President NEWTON in the chair.

It was announced that the Association Post Office would be open on Sunday, from 9.30 to 10.30 A. M.

The PRESIDENT introduced Capt. E. L. CORTHELL of New York, who delivered the lecture of the evening, entitled "The inter-oceanic problem, and its scientific solution."

SATURDAY was devoted to the enjoyment, by nearly all the members in attendance, of the excursion provided by the liberality of the citizens of Detroit, which passed off with remarkable smoothness and perfection of arrangement, and was very greatly enjoyed by all the participants. Taking an early train to Detroit and there passing on to the steamer, the excursionists were conveyed to the rock salt wells at Marine City, and after a most interesting visit to the salt works, were taken farther to the Oakland House on the St. Clair River, where they found awaiting them a sumptuous repast, which was seriously appreciated. On the return, Detroit was reached at early evening, and a special train was found waiting to carry those who wished back to Ann Arbor.

MONDAY MORNING, AUGUST 31.

President NEWTON in the chair.

The GENERAL SECRETARY read the following letter:

ANN ARBOR, MICH., AUG. 31, 1885.

The Observatory will be open to visitors this afternoon from 2 to 6 o'clock, and in the evening from 7.30 to 11 o'clock; and to-morrow afternoon and evening at the same hours.

J. W. SCHAEBERLE.

The following Members were elected by ballot as Fellows of the Association:

Abbott, Helen C. DeS., 1509 Locust St., Philadelphia, Pa. (33).
Adams, Frank, 41 McGill College Avenue, Montreal, Can. (29).
Agnew, Dr. Cornelius R., 266 Madison Avenue, New York, N. Y. (32).
Alden, Prof. Geo. I., Worcester, Mass. (33).
Ayres, Prof. Brown, Tulane University, New Orleans, La. (31).
Babcock, S. Moulton, N. Y. Agric. Experiment Station, Geneva, N. Y. (33).
Barnes, Prof. Chas. R., 297 Columbia St., Lafayette, Ind. (33).
Bayne, Prof. Herbert A., Ph.D., Royal Military College, Kingston, Ont. (29).
Beardsley, Prof. Arthur, Swarthmore College, Swarthmore, Del. Co., Pa. (33).
Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31).

Boardman, Mrs. Wm. D., 38 Kenilworth St., Roxbury, Mass. (28).
Bond, Geo. M., The Pratt and Whitney Co., Hartford, Conn. (33).
Bourke, John G., Capt. 3rd Cavalry, U. S. A., care Adj. Gen. U. S. A., Washington, D. C. (33).
Brashear, Jno. A., 3 Holt St., Pittsburg, S. S., Pa. (33).
Brinton, Daniel G., M.D., Media, Pa. (33).
Butler, A. W., Brookville, Franklin Co., Ind. (30).

Cooley, Prof. Mortimer E., Univ. of Mich., Ann Arbor, Mich. (33).

Davis, Prof. Wm. Morris, jr., Cambridge, Mass. (33).
Doolittle, Prof. C. L., South Bethlehem, Pa. (25).
Douglass, Andrew E., P. O. Box 605, New York, N. Y. (31).

Eaton, Prof. James R., Liberty, Mo. (29).
Elkin, William L., Yale College Observ., New Haven, Conn. (33).

Fanning, John T., Manchester, N. H. (29).

Gibbs, Prof. J. Willard, New Haven, Conn. (33).
Gladding, Thomas S., Box 1261, New York, N. Y. (30).
Grinnell, G. B., 39 Park Row, New York City (25).

Hallock, Albert P., Ph.D., 249 East 31st St., New York, N. Y. (31).
Hart, Edw., Ph.D., Easton, Pa. (33).
Haupt, Prof. Lewis M., University of Pennsylvania, Philadelphia, Pa. (32).
Heilprin, Prof. Angelo, Acad. Nat. Sciences, Philadelphia, Pa. (33).
Hendricks, J. E., Des Moines, Iowa (29).
Hering, Rudolph, 326 Walnut St., Philadelphia, Pa. (33).
Hicks, Prof. Lewis E., State Univ., Lincoln, Neb. (31).

Jenkins, Edw. H., New Haven, Conn. (33).

Kimball, Arthur Lalanne, Johns Hopkins Univ., Baltimore, Md. (33).
Kolbe, C. W., Ph.D., 32 Longwood Ave., Cleveland, Ohio (33).

La Flesche, Francis, Indian Bureau, Interior Dept., Washington, D. C. (33).
Lehman, G. W., Ph.D., 57 So. Gay St., Baltimore, Md. (30).

McAdams, Wm., Alton, Ill. (27).
McNeill, Malcolm, Princeton, N. J. (32).
Merriam, C. Hart, M.D., Locust Grove, Lewis Co., N. Y. (33).
Merriman, Prof. Mansfield, Lehigh Univ., Bethlehem, Pa. (32).
Metz, Charles L., M.D., Madisonville, Hamilton Co., Ohio (30).
Murdock, J. B., Lieut. U. S. N., 24 Alaska St., Roxbury, Mass. (28).

Noyes, William A., Ph.D., Univ. of Tennessee, Knoxville, Tenn. (32).

Owens, Mary E., 270 W. 7th St., Cincinnati, Ohio (30).

Paul, Prof. Henry M., U.S.N. Observ., Washington, D. C. (33).

Peabody, Prof. S. H., Regent Illinois Industrial Univ., Champaign, Ill. (30).
Pillsbury, Prof. John H., Smith College, Northampton, Mass. (23).
Richards, Prof. Charles B., 43 Elm St., New Haven, Conn. (33).
Salmon, Daniel E., Dep't of Agric., Washington, D. C. (31).
Sewall, Prof. Henry, Ann Arbor, Mich. (34).
Smith, Prof. Charles J., Cleveland, Ohio (32).
Stevenson, James, Ass't Ethnologist, Washington, D. C. (29).
Stillwell, Charles M., Box 1261, New York, N. Y. (30).
Stowell, Prof. T. B., Cortland, N. Y. (28).
Stringham, Prof. Irving, Univ. of Cal., Berkeley, Cal. (33).
Taylor, Thomas, M.D., Dept. of Agric., Washington, D. C. (29).
Thomson, Wm., M.D., 1426 Walnut St., Philadelphia, Pa. (33).
Underwood, Prof. Lucien M., 214 East Genesee St., Syracuse, N. Y. (33).
Vogdes, A. W., 1st Lt. 5th Art'y, U. S. A., The Military Service Institution, Governor's Island, N. Y. (32).
White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29).
Whitman, Prof. Frank P., Rensselaer Polytechnic Inst., Troy, N. Y. (33).
Williams, Prof. S. G., Cornell Univ., Ithaca, N. Y. (33).
Wilson, H. C., Cincinnati Observatory, Mt. Lookout, Hamilton Co., Ohio (30).
Winlock, Wm. C., U. S. Observ., Washington, D. C. (33).
Woodward, R. S., care U. S. Geol. Survey, Washington, D. C. (33).
Wright, Elizur, Box 109, Boston, Mass. (31).

It was announced that the STANDING COMMITTEE had voted that all members of committees must be members or fellows of the Association.

A call was then made for reports of committees.

Committee 1 presented no report and was continued.

Committee 2 had previously reported.

Committee 3 reported progress and was continued.

Committee 4 reported progress and was continued.

Committee 5 presented a printed report, which was accepted; and the committee reconstituted as follows:

Committee on Stellar Magnitudes.

E. C. PICKERING of Cambridge,	S. W. BURNHAM of Chicago,
ASAPH HALL of Washington,	WILLIAM HARKNESS of Washington,
E. S. HOLDEN of Madison,	SIMON NEWCOMB of Washington,
ORMOND STONE of Univ. of Va.,	C. A. YOUNG of Princeton.

Committee 6 presented a written report which was accepted. The title of the Committee was changed to "*Committee on International Scientific Congress,*" and the committee was then continued.

Committee 7 presented a written report which was referred to section C to be read. The Committee was then continued.

Committee 8 presented an informal report of progress and was continued.

Committee 9 reported progress and was continued.

Committee 10 reported progress and was continued. The correspondence with Admiral Bedford Pym in regard to the meeting of the Association in London was referred to this committee.

Committee 11 reported progress, was enlarged by the addition of

S. F. BAIRD of Washington,
SIMON NEWCOMB of Washington,
T. C. MENDENHALL of Washington,

and was continued.

Committee 12 presented an informal report and was discharged.

Committee 13 made no report and was discharged.

Committee 14 reported progress, and was reconstituted as follows:

HARRISON ALLEN of Philadelphia,
H. OSBORN of Ames,
T. B. STOWELL of Cortland,
B. G. WILDER of Ithaca,

and was continued.

Committee 15 presented a written report which was accepted. The committee was continued after being reconstituted as follows:

J. C. ARTHUR of Charles City,
C. E. BESSEY of Lincoln,
T. J. BURRILL of Champaign,
W. G. FARLOW of Cambridge,
C. V. RILEY of Washington.

Committee 16 presented no report and was discharged.

Committee 17 presented a report which was referred to section F, and was continued.

Committee 18 had performed its duties and was continued.

TUESDAY MORNING, SEPTEMBER 1.

President NEWTON in the chair.

Prof. S. G. WILLIAMS was elected Assistant General Secretary for this meeting.

The following officers for the ensuing year were elected:—

President: E. S. MORSE, of Salem, Mass.

Vice Presidents: **A.** *Mathematics and Astronomy*—J. W. GIBBS of New Haven, Conn. **B.** *Physics*—C. F. BRACKETT of Princeton, N. J. **C.** *Chemistry*—H. W. WILEY of Washington, **D.** *Mechanical Science and Engineering*—O. CHANUTE of Kansas City, Mo. **E.** *Geology and Geography*—T. C. CHAMBERLIN of Washington, **F.** *Biology*—H. P. BOWDITCH of Boston, Mass. **H.** *Anthropology*—HORATIO HALE of Clinton, Ont. **I.** *Economic Science and Statistics*—JOSEPH CUMMINGS of Evanston, Ill.

Permanent Secretary: F. W. PUTNAM of Cambridge, Mass. (holding over).

General Secretary: S. G. WILLIAMS of Ithaca, N. Y.

Assistant General Secretary: W. H. PETTEE of Ann Arbor, Mich.

Secretaries of the Sections: **A.** *Mathematics and Astronomy:*—S. C. CHANDLER of Cambridge, Mass. **B.** *Physics*—H. S. CARHART of Evanston, Ill. **C.** *Chemistry*—WM. MCMURTRIE of Champaign, Ill. **D.** *Mechanical Science and Engineering*—WILLIAM KENT of Jersey City, N. J. **E.** *Geology and Geography*—E. W. CLAYPOLE of Akron, Ohio. **F.** *Biology*—J. C. ARTHUR of Geneva, N. Y. **H.** *Anthropology*—A. W. BUTLER of Brookville, Ind. **I.** *Economic Science and Statistics*—H. E. ALVORD of Mountainville, N. Y.

Treasurer: WILLIAM LILLY of Mauch Chunk, Pa.

It was voted to hold the next meeting in Buffalo, N. Y., commencing Wednesday, Aug. 18, 1886.

Dr. CHARLES S. MINOT proposed the following amendments to the Constitution.

1. To refer the election of fellows to the Standing Committee.
2. To have all reports of committees presented to the Standing Committee and only such reports read in General Sessions as the Standing Committee shall direct.
3. To have two fixed General Sessions, one for the opening and one for the closing exercises, and such other General Sessions as the Standing Committee shall determine.
4. That the Standing Committee appoint at its first session during the annual meeting three sub-committees, to hold office during the meeting—1, On papers and reports; 2, On members; 3, On fellows.

TUESDAY EVENING, SEPTEMBER 1.

President NEWTON in the chair.

It was voted upon recommendation of the STANDING COMMITTEE to appoint the following "*Committee on Physics Teaching:*—"

T. C. MENDENHALL of Washington.
W. A. ANTHONY of Ithaca.
H. S. CARHART of Evanston.
F. H. SMITH of Charlottesville.
JOHN TROWBRIDGE of Cambridge.

Dr. C. S. MINOT moved that the following resolution be passed.

RESOLVED:—That the very cordial and hearty thanks of the Association be extended in grateful acknowledgment:—

To the authorities of the University for the generous hospitality which has accorded to us such fine and ample accommodations for all our meetings, and to President Angell for the welcome he so warmly extended to us, which has been emphasized by fact as well as word.

To the Citizens of Ann Arbor for their innumerable courtesies, which

have made every day a pleasure and the whole meeting thoroughly satisfactory and enjoyable. To the Local Committee and Judge Cooley its chairman for the very admirable and perfect arrangements they have made throughout—to Judge Harriman and Mrs. Gov. Ashley and the Ladies' Reception Committee for the delightful and successful reception at the Court House.

To Prof. Alex. Winchell and the members of the Excursion Committee for their devoted labors and the valued excursion privileges they have secured us.

To Maj. Harrison Soule and the Transportation Committee for the advantages they have secured for us, favoring the coming and speeding the parting guest.

To the City Council and Mayor for the important and essential contributions they have made to the welfare and prosperity of this meeting.

To the Ladies of Ann Arbor for the charming lawn party in the University Campus.

To the Citizens of Detroit for the excursion provided by their liberality, which nearly all of us eagerly profited by and greatly enjoyed.

To Prof. W. H. Pettee for his steadfast supervision of the printing, in consequence of which the daily programme has always been issued promptly.

To the Local Secretary, Prof. J.W. Langley, for his rare devotion to the advancement of every interest connected with this meeting, and his unremitting attention to everything which could promote the success and pleasure of this meeting.

Dr. CHARLES S. MINOT then presented to Prof. J. W. LANGLEY on behalf of the Association and in accordance with the unanimous vote of the STANDING COMMITTEE a complete set of the Publications of the Association, which was placed upon the table by the PERMANENT SECRETARY. Prof. WM. HARKNESS seconded the motion.

Prof. LANGLEY, although taken completely by surprise at this action of the Association, in very felicitous terms expressed his appreciation of the thanks and the gift made to him by the Association.

The previous motion was then ably seconded by Messrs. COPE, DORSEY, BESSEY, BRASHEAR, HALE, MACFARLAND, and ROCKWELL and was carried with great applause by a unanimous vote.

The PERMANENT SECRETARY gave the following statistics of the meeting:

Three hundred and sixty-four members have registered during the present meeting. One hundred and fifty-four new members have been elected.

The members in attendance by states and from Canada are as follows: Michigan 78, New York 49, Ohio 37, Illinois 33, Massachusetts 31, District of Columbia 23, Pennsylvania 17, Indiana 14, Iowa 12, Wisconsin 9, New Jersey 7, Nebraska 6, Minnesota 5, Tennessee 5, Kentucky 5, Missouri 4, Kansas 4, Texas 4, Canada 3, Florida 3, Rhode Island 3, Mississippi 3, Connecticut 2, Maryland 1, Virginia 1, Alabama 1, Louisiana 1, Vermont 1, Arkansas 1, Wyoming Territory 1, = 364.

The papers read and addresses delivered during the meeting were as follows:—President's Address, 1; Vice Presidents' Addresses, 7; lecture in General Session, 1; papers before Section A, 12; Section B, 23; Section C, 18; Section D, 12; Section E, 27; Section F, 32; Section G, 4; Section H, 26; Section I, 21=184.

President NEWTON made a few remarks and declared the thirty-fourth meeting of the Association adjourned.

CHARLES SEDGWICK MINOT,
General Secretary.

After the formal close of the meeting a number of the members went on the excursion provided by the Local Committee to Mackinaw Island, enjoying both that and subordinate excursions to Petoskey, Sault St. Marie and Marquette.

C. S. MINOT.

F. W. PUTNAM, PERMANENT SECRETARY,

Dr. THE AMERICAN ASSOCIATION FOR

1884–5.

To Assessments previous to 33d Meeting .	$ 798 60	
" for " " . .	3,312 00	
" " 34th " . .	663 00	
" from Associate Members . .	396 00	
		$5,169 00
Admission fees previous to 33d Meeting .	20 00	
" " for 33d Meeting . .	1,990 00	
Fellowship fees	66 00	
		2,076 00
Publications sold and binding . . .	134 76	
Incidental receipts	2 63	
		137 39
Life membership commutations . .		250 00
Balance due Permanent Secretary . .		1,087 78
		$8,720 26

I have examined the above account and find

SALEM, MASS., AUG. 1, 1885.

IN ACCOUNT WITH

THE ADVANCEMENT of SCIENCE. Cr.

1884–5.

By 3000 copies Proceedings, Vol. 33, Philadelphia Meeting:—			
Composition and extra corrections	$1,063 80		
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			$ 4,316 49
General expenses, Philadelphia Meeting	649 16		
1000 list of members, constitution, etc.	171 14		
			820 30
Special expenses, Section D, Philadelphia Meeting	38 85		
Circulars, Section D, Ann Arbor Meeting	22 00		
" " I, " " "	3 75		
			64 60
Publications, 17.00; binding, 15.25			32 25
Printing circulars, blanks, tickets, etc.	255 05		
Express	78 16		
Telegraph, telephone and cable	23 76		
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Post Office box rent	8 00		
Subscriptions to Postal Guide	1 50		
			529 99
Office rent	100 00		
Fuel	12 00		
Janitor	54 59		
Incidental office expenses	36 33		
			202 92
Extra clerk hire	31 22		
Salary of Assistant Secretary	500 00		
Salary of Permanent Secretary	1,000 00		
			1,531 22
Paid Permanent Secretary bal. due on last acc't			1,222 49
			$8,720 26

the same correctly cast and properly vouched,

HENRY WHEATLAND, *Auditor.*

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